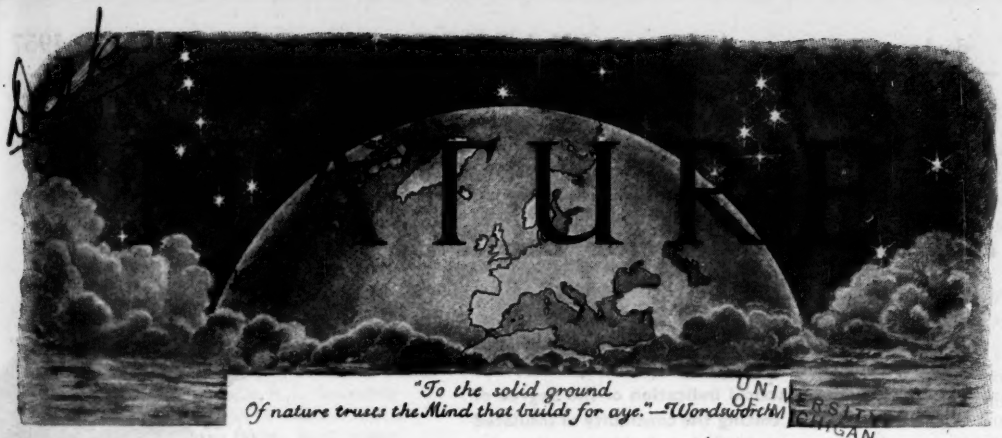

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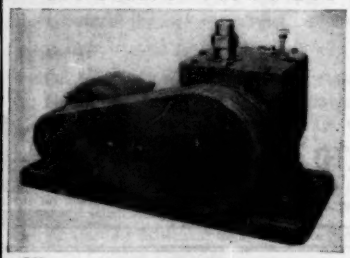

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NATURE

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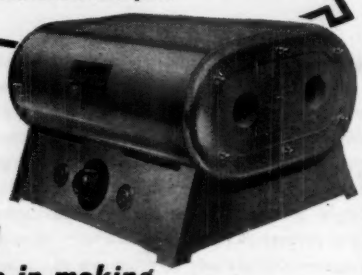

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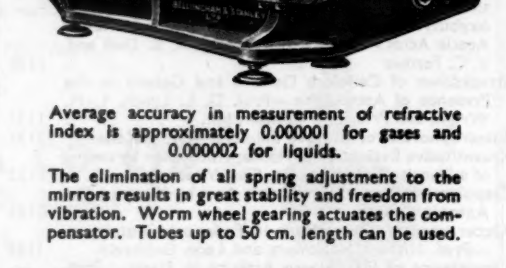

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POWER RESOURCES OF THE FUTURE IN BRITAIN

WHEN the Minister of Power, Lord Mills, and Mr. R. Maudling, speaking for him in the House of Commons, made the long-awaited statement regarding Britain's nuclear power programme on March 5, requests for a White Paper, particularly on Britain's energy resources, were made in both Houses. The Government agreed to consider this request, and in April a White Paper was issued accordingly, dealing with capital investment in the coal, gas and electricity industries. This paper was discussed in the House of Commons on April 30, when Mr. Maudling gave a clear exposition of the fuel and power policy of Great Britain, particularly in relation to the investment programme described in the White Paper.

Dealing with the general energy problems of Britain, the probable demands on energy resources and the best methods which could be adopted to meet that demand, the Postmaster-General suggested that we might be at the beginning of a new phase in our fuel and power policy, and that in the next few years profound changes in the whole energy position was possible. Since the War we have been working, he said, on quite inadequate margins of fuel supply and recent events have emphasized the difficulties attending the import of oil, particularly the rate at which the world demand for oil is growing, the pressure on oil supplies and the means of transport; in addition, the rapid progress achieved in the production of nuclear power promises to change the picture further.

Britain's energy policy, accordingly, should first ensure an adequate supply to meet the demands both of industry and the domestic user, and, secondly, indigenous sources of energy should make the maximum possible contribution to the balance of payments. Policy should also, he thought, err on the side of boldness, but it must also be flexible, and we must be prepared to modify it to meet changing circumstances, either from rapid and unpredictable technical advance or from the changes in the total demand for different fuels. So far as possible, we should allow the balancing of demand and supply of energy to be determined by normal commercial considerations; but the Government must be prepared to intervene where necessary to secure that the principles he had indicated were served.

The picture Mr. Maudling then presented was that, over the decade 1955–65, the demand in Great Britain for coal and its equivalents is expected to rise from 250 million tons to 300 million tons, and it is hoped also to secure another 10 million tons as a contribution to the net export position. By the end of 1965, the nuclear power stations in Britain should be producing electricity equivalent to that now obtainable from 18 million tons of coal, but which should then be obtainable from 14 million tons. This would still leave the equivalent of about 26 million tons of coal to be imported as oil, an increase of more than 50 per cent on the present imports, towards which it is improbable that more than two or three million tons could be produced in Britain itself.

Mr. Maudling then referred to probable changes in the pattern of demand. That for coal for carbonization is expected to develop rapidly, as is the demand for smokeless fuel in connexion with clean air policy, while the demand for secondary fuels, especially electricity, seems likely to grow much faster than the general demand for energy. Moreover, the increasing proportion of small coal in the British output is already a difficulty, which will be enhanced when nuclear power stations displace the conventional power stations that take much of the small and poor-quality coal. Mr. Maudling recognized the over-riding problem of price relationships, though he passed over the use of fiscal policy to encourage the domestic production of, for example, shale oil. He thought that the plans of the gas and electricity industries are likely to meet the demand during the next few years, and that in the nuclear field we should exploit our position to the full and pay particular attention to reducing the capital cost of the new stations, while finally he emphasized the importance of fuel conservation. By 1965 about a quarter of the electricity supply of Britain will be derived from nuclear sources, but by the early 1970's this should be more than 40 per cent. Important problems have still, however, to be solved, especially in regard to the flexibility of operation of these stations, and obviously it is desirable that the power required should be produced by as few stations as possible. Much attention is accordingly being given to obtaining the maximum power from individual stations, but the possibilities of the direct use of nuclear power in industry is also being examined.

Mr. Maudling then took the statement on capital investments as read and did not refer specifically to the figures given in the White Paper*, which are limited to those for 1956 and 1957, apart from those relating to the cost of the expanded nuclear programme which are appended. For 1957, approved capital expenditure totals £440 million, compared with £390 million in 1956; of this, £107 million is for the National Coal Board, £233 million for the Central Electricity Authority and Area Boards, £20 million for the South of Scotland Electricity Board, £25 million for the North of Scotland Hydroelectricity Board and £59 million for the Gas Council and Area Boards. Of the £233 million for the Central Electricity Board, only £12 million is for nuclear generating stations, compared with £108 million on conventional stations, but a table in an appendix to the White Paper dealing with the revised nuclear power programme shows the estimated effect on the

* Capital Investment in the Coal, Gas and Electricity Industries. Pp. 12. (Cmnd. 132.) (London: H.M. Stationery Office, 1957.) 8d. net.

capital budgets of the Central Electricity Authority and the South of Scotland Electricity Board of bringing into operation 6,000 MW. of nuclear output capacity by the end of 1965. This total capital investment is expected to increase from an average of £226 million in 1956–57 to an average of £400 million per annum over the five years 1961–62 to 1965–66, compared with £270 million for a hypothetical conventional programme, and to represent a capital expenditure on generation, transmission and distribution of £3,350 million during the period 1950–57 to 1965–66 (of which £1,079 million is on nuclear stations, including £160 million on stations coming into commission after 1965), compared with an estimated £2,600 million if all the generating plant commissioned or constructed during the period was conventional.

Mr. Maudling's review was well received in the House of Commons, though it was suggested that he outlined plans rather than a definite policy, and in replying on the debate, Mr. D. Renton, the Parliamentary Secretary to the Ministry of Power, added little to what Mr. Maudling had said; nor did Mr. Renton attempt to dispel whatever fears had been expressed as to the magnitude of the investment proposals in relation to other demands on resources, or as to whether the measures for securing the integration of resources of fuel and power are really effective enough. Since the debate, moreover, the Central Electricity Authority has indicated that the nuclear power station proposed at Hinkley Point, Somerset, for which a final tender is to be submitted by the end of June, will have a net output of 500,000 kW.—more than eight times that of Calder Hall and half as much again as that of the nuclear power stations for which contracts were let last September—while its cost, kilowatt for kilowatt, is about the same. It is thus clear that nothing like the sixteen new nuclear power stations which Lord Mills on March 5 thought would suffice will be required to provide 6 million kW. of capacity by 1965, and it should be well within the capacity of British firms to provide much more capacity by that date even from a dozen or so power stations.

While there is thus more elbow room for fuel policy in Britain than was assumed in the debate in the House of Commons on April 30, it is still impossible for independent judgment to be formed on the effect of proposals for energy production on the balance of scientific and technical resources generally. Expenditure on research and development for 1957–58* is estimated at £258,695,233 in a memorandum by the Financial Secretary to the Treasury, dated February 19; but although this includes £206,500,000 on research and development for the Ministry of Supply, partly for civil and partly for defence purposes, it includes no figures for expenditure on nuclear research and development under the Lord President of the Council. Research and development for the Atomic Energy Authority, like those for the Central Electricity Authority and the other nationalized industries, are thus outside the Civil Estimates, nor are they given in the White Paper, which is restricted to capital investment. Furthermore, the effect on man-power resources could be no less serious, and neither Mr. Maudling nor Mr. Renton did more than parry inquiries on this point. They showed that the Government is aware of the danger, and that its proposals for the expansion of technical and technological education are intended to remove it.

Nothing has, however, as yet been forthcoming from the Government side to indicate whether in fact the economy of Britain is being seriously distorted in this way and, if so, whether any emergency or temporary measures are being taken to minimize such damage. Sir John Cockcroft said in Rome on April 3 that such developments of new types of reactor require a staff of about a hundred scientists and could cost half a million to a million pounds a year over five years, apart from the cost of building experimental reactors as prototypes. He admitted the need for discrimination in the choice of reactor projects, and although we are working on a so-called fast-breeder reactor, this involves difficult development problems (see *Nature*, May 25, p. 1048) and is unlikely to come into large-scale use before about 1970.

In that address Sir John gave some indication of British plans for such technological developments, particularly in regard to the use of plutonium and for increasing the output of nuclear power stations, but without indicating further the magnitude of the demand which such developments will make on scientific and engineering man-power. Nor did his address at Baghdad on the opening of the Baghdad Pact Nuclear Centre on March 30 add anything significant to what Sir Christopher Hinton said in Stockholm, on March 15, about the cost of producing electrical energy from nuclear power. Addressing the Parliamentary and Scientific Committee on March 12, Sir John expressed his confidence that we shall find the additional technical man-power required for our nuclear power programme, nor was his view challenged in the subsequent discussion.

There is, however, a further aspect which was scarcely mentioned in the House of Commons on April 30 and only touched on at the meeting of the Parliamentary Committee on March 12 about the development of package nuclear reactors for export; in reply to a question, Sir John replied that by the end of this year the authorities expect to know much better which of the three possibilities under examination is worth developing. The report, published on May 8, of the three experts instructed by the Euratom Powers in November to consider the amount of nuclear energy which can be produced in the near future in the six countries, and the means to be employed for this purpose, indicates that, to begin developing nuclear power quickly, Euratom must either buy reactors from the United States and the United Kingdom or build them on licence. The six countries, moreover—Belgium, France, Germany, Italy, Luxembourg and the Netherlands—are recommended to start on a joint programme of construction

* 1957–58 Civil Estimates and Estimates for Revenue Departments for the year ending 31st March, 1958. Pp. 43. (London: H.M. Stationery Office, 1957.) 2s. 6d. net.

which by 1967 will give them 15 million kW. of generating capacity from nuclear reactors, and most of the calculations made in the report assume that half the reactors needed will be of the British type and half of the American type, the only two ready for commercial use.

The recommendation is based on the imperative need to halt as soon as practicable the growth of Europe's imports of energy—at present 23 per cent in the six countries, compared with Britain's 12 per cent; but it is clearly in Britain's interest to exploit to the full the opportunity which her scientists and technologists have put within her reach. This opportunity may well offer a more solid advantage in the balance of payments, on which Mr. Maudling rightly laid stress, than will the development of the package reactors on which Sir John Cockcroft was questioned. The latter are important rather for the underdeveloped countries, and their contribution to our economic position is likely to be indirect, though they too represent an opportunity which should be fully utilized and for which both scientific and technical man-power must be found.

Wide therefore as the House of Commons debate on April 30 ranged, neither that debate nor the White Paper on Capital Investment in the Coal, Gas and Electricity Industries sets this question of energy and fuel in the essential context of its relation to the total scientific and technical resources of Britain. For that it is essential to have the overall view which the Lord President's office should be able to supply, but which is denied in the Treasury Memorandum on the Civil Estimates so far as research and development are concerned. If it is unwise, for security reasons, to supply figures which would permit independent judgment and impartial criticism of the distribution of scientific and technical effort in Britain, it should at least be possible for such a body as the Advisory Council on Scientific Policy to make an authoritative survey and issue a report which would give sufficient information to reassure scientific and technological circles in Britain as well as industry on a matter of critical importance. Errors of judgment in this field, and failure to allocate effort wisely, unless corrected early, could well impose strains on the economy and issue in waste of effort or resources as well as frustration, which could defeat the intentions and plans which Mr. Maudling outlined to Parliament.

LABORATORY ADMINISTRATION

Laboratory Administration

By E. S. Hiscocks. Pp. xvi+392+8 plates. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1956.) 36*s*. net.

THERE is often some prejudice against the scientist turned administrator, and perhaps more, and more justly, against the scientist with a heavy administrative charge who fails to realize his wider responsibilities. Scientists in a laboratory tend, as the author of this book puts it, "to call all decisions not made by them or their juniors, 'administration', and to regard administration as something specially designed to frustrate their efforts to get on with their job". Mr. Hiscocks, for years the secretary of the National Physical Laboratory, must have been in an admirable position to note this approach, and in undertaking the writing of this book, must have known well that practising scientists might regard it as an attempt to glorify administration; and administrators to regard it as amateur's analysis of a not very important aspect of their business.

Either judgment would be unfair. The book may have faults, as it certainly has gaps; it may analyse too little foreign and industrial practice, as it certainly refers too much to Civil Service practice; it may cover method too much while studying the aim too little; yet it is a thoroughly useful, sensible account of many aspects of its subject, written by a man who has great personal experience of the subject on which he writes and who has also taken the trouble to read very widely in this field and to quote wisely and selectively.

At times the informed reader will think the author is pushing at an open door, if, as I believe, most scientists working in a large organization—and most do—are just as well prepared to obey, indeed to use, sensible administrative instructions as are members of any other profession, provided their aim is clear and their operation sympathetic. At times the author seems to exaggerate the different approach to administration by the scientist. This he may do the better to make his point, or he may be reflecting the feelings of an earlier era when, particularly in the Civil Service, there was very little understanding of the real special requirements of the scientist, or of the necessary personal consequences of his academic discipline.

It is ten years since the Second World War gave scientists their chance to show their administrative mettle, ten years since the Barlow Report, and nearer forty years since the great research organizations throughout the world began to show the way.

The general lay-out of the book is simple. An introductory chapter on general considerations successfully sets out the main problems the author will discuss. The next, on the "Head of the Establishment", makes some good points and injects some sensible warnings, though to some it may be marred by a tendency to use opinion as evidence, and to write down the true value of scientific leadership in a director, perhaps on account of the author's failure to believe that special aptitude and high general ability are closely allied. A necessary chapter on "Functions of Staff", starting from a Civil Service angle, is rather less satisfactory to me, because I doubt if the gulf between scientist and administrator is indeed so wide as the author says. The next chapter, on recruitment and staff, biased perhaps even more heavily by Civil Service practice, I find very satisfactory, perhaps because Mr. Hiscocks thinks that the Civil Service on the whole, with help from the staff side, manages these things rather well. This section is very clear, factual and to the point. It could well be read by industrial employers. There follows a study of assessment, promotion and transfers, peculiarly thorough, analysing methods in use in Britain and in America. Adequate samples of the various merit assessment forms are provided. Jar they may, irritate the reporting officer they certainly do. But as they do provide a check on progress, supplement and help interviewing boards and provide grounds for accelerated promotion or disciplinary

action, they must be used and are here to stay. The author's comments are fair and useful. The very difficult problem of retirement is also treated fully.

There follow a rather parochial chapter on "Staff Relations and Welfare" and a useful selection of ideas on "Flow of Information". Finance is lightly handled: it is time a real study was published on the value and difficulty of costing research and development in a laboratory. Programming is discussed fairly fully in the light of the author's own experience; on "Evaluation", he rather courageously suggests a scheme which might well be tried.

Chapters on "General and Technical Services" are again a little local in emphasis, and on "Laboratory Buildings" sketchy. The section on "Patents, Copyright and Trade Marks" is very useful, and the concluding one on "Training for Management" one of the best in the book. Twenty-two well-selected appendixes and an admirable bibliography document it; the plates scarcely adorn it and do little to illustrate it.

This, then, is a useful book, partly compilation, partly suggestive, rarely critical, generally personal. It would do good if every aspirant to a senior position in a large laboratory, industrial or government, read it soon after he joined, re-read it ten years later, and reserved his criticisms for another ten years.

O. H. Wansbrough-Jones

AUTOMATION AND SOCIETY

Automation and Social Progress

By Dr. S. Lilley. Pp. 224. (London: Lawrence and Wishart, Ltd., 1957.) 21*s*. net.

Automation

Its Purpose and Future. By Dr. M. Pyke. Pp. 191 + 8 plates. (London: Hutchinson's Scientific and Technical Publications, 1956.) 16*s*.

Automation in Theory and Practice

A Course of Lectures organised by E. M. Hugh-Jones. Pp. ix + 140. (Oxford: Basil Blackwell, 1956.) 12*s*. 6*d*. net.

THESE three books are all intended for the general reader rather than the specialist, and as such they are all good in parts. Unfortunately, they all demonstrate that when a writer strays from his own subject he is likely to be inaccurate in both substance and implication. In this matter, Dr. Pyke is the worst offender and Dr. Lilley the least, while at Oxford the experts are above suspicion, although the later and more general lectures are misleading in some respects.

Technically, Dr. Lilley's book is by far the best I have yet seen: his history of automation is excellent, particularly of what has been done in the U.S.S.R., and his discussion of what is likely to happen in the future and of the requirements to make automation effective in Britain is reasonable. This discussion is based on well-documented information and his conclusions are far-seeing and important. It is therefore most unfortunate that, when he deals with economic and political matters, what he says is highly coloured by his political views. He is quite convinced that automation cannot be properly developed for the benefit of all in a capitalist society, on which he pins the blame for most of our economic troubles. He thinks that the capitalist system is doomed, but fears that socialism will come to Britain too late. Fortunately, he accepts that we shall continue with a capitalist system for several years and considers what can best be done with such a system. The requirements to make the best use of automation in our capitalist society are carefully worked out and deserving of close attention by those who plan our education, economics and production methods. Dr. Lilley has not only visited the U.S.S.R. but has studied the literature closely, and he quotes at length from the directives of the Twentieth Congress of the C.P.S.U. on the sixth five-year plan given in "The Development of the U.S.S.R. (1956–60)". These directives are of very great interest because they show the importance which is attached to the development of automation by the leading Russian statesmen, and also the careful plans which they have for its development, plans which might well be emulated elsewhere in Europe. Earlier in the book, Dr. Lilley pointed out that the Russians have deliberately pursued a different course of development from that followed in America and Europe, and as a result, although it started as a technologically backward country, the U.S.S.R. has been the first to have an automatic factory with no direct labour employed in it. In the Automatic Piston Factory which was operating in 1950, and in the Automatic Ballbearing Factory, the Russians set themselves far more difficult tasks than have yet been undertaken in Europe. By carrying out these major schemes, they have paved the way for a much more widely spread application of automation than would have been possible if they had been content with developing and equipping their factories with large numbers of transfer machines and digital computers. In these complete automatic factories, they came up against problems which were difficult to solve, and it is probable that, taking into account the cost of development, the factories were not economically justifiable; but having brought the projects to a successful conclusion, they now have a wide experience in automation techniques.

Dr. Pyke starts by saying that he cannot claim to be an expert on automation but he has tried to write down what seems to him to be happening, and why he thinks it is urgent and important. It is unfortunate that the early part of the book, in which he is discussing automation as applied to mechanical engineering, is full of errors. When he comes to automatic chemistry and the petroleum industry, he is on safer ground, and his description of what has been done is excellent. Dr. Pyke goes on to describe what has been done and what might be done in the application of automation to fields other than manufacture, such as accounting, transport, food and catering and the distributive trades. So far as I know, this is the first time that this information has been gathered together into a single book, and although, of course, Dr. Pyke has had to draw on articles in technical and trade journals to obtain his information, it is none the worse for that. Dr. Pyke then goes on to discuss guided weapons, which again is a field in which he has no experience, and this chapter has several errors of fact. His chapter on automatic translation is interesting and, in general, accurate, while his final chapters on "Automation—How Soon?" and "Life Automatic" should be read by all interested in the subject, since his philosophical views are excellent.

The lectures at Oxford are in a different category from the other books, and although they were also aimed at the general reader rather than the specialist,

they include more information of value to the specialist rather than to the general reader. The earlier lectures, which deal with technical matters, are excellent, and some of the data given in Mr. Argyle's lecture on "Social Aspects" are of the greatest value to those concerned with planning automation. Mr. Spencer's lecture on "Administrative Applications of Automation" includes two appendixes which give the typical work of an administrative office and a simplified description of a computer, which will be valuable to managing directors planning to install computers in their firms, but the remainder of his lecture is in too general terms to be useful. The most impressive of the lectures is, I think, that of Mr. Nicholas on "The Trade Union Approach to Automation". Anyone who has taken part in discussions on automation with trade union officials will already know how sensible and realistic is the trade union approach, and this lecture is a model of reasoned exposition based on sound premises. He emphasizes many of our failings both in planning and in industry, and points the way of their correction. Finally, let me quote what he says we expect of automation, and which will be agreed by all whatever their political views: "If we want higher wages, shorter hours, better education, improved pension schemes, we have to be able to afford them. Automation provides one way to assist in achieving those things. It is by no means the complete answer but, inasmuch as it can have a profound effect upon our future wellbeing, we must welcome it and not fear it, we must control it and not allow it to submerge us, and its advantages and benefits must be enjoyed by the many and not utilized for the privilege of the few".

JOHN F. COALES

ELECTRONIC COMPUTERS

Electronic Computers

Principles and Applications. Edited by T. E. Ivall. Pp. viii+167+53 plates. (London: Iliffe and Sons, Ltd.; New York: Philosophical Library, 1956.) 25*s*. net.

THIS book is intended to serve as a non-mathematical introduction to the principles and application of digital and analogue computers primarily for technicians, engineers and students, but also for business executives. It starts with a historical introduction to computers, and follows with a general introduction to computing in which the differences between analogue and digital machines are discussed. Thereafter the analogue and digital machines are treated separately.

In the description of analogue computer circuits the broad principles tend to be overshadowed by details. In particular the principle of negative feedback does not seem to be very well emphasized and the 'virtual earth' concept in d.c. feedback amplifiers is introduced in an indirect manner. The simpler circuits discussed include those for reversal of sign, summation, integration and differentiation, and the manner in which the circuits are connected to solve a differential equation is explained. A number of function generators are described using masked cathode ray tubes and biased diodes, and two forms of multiplier are mentioned briefly.

In the chapter on equipment for analogue computers the approach is as if the reader was being shown one of these machines for the first time. While this type of approach is interesting, and a number of practical points including power-supply stabilization are brought out, it tends to obscure some of the more fundamental design features. There is a good general account of the applications of analogue computers including aircraft design problems, flight problems using TRIDAC, pilot training simulators and auto-correlation.

The remainder of the book, rather more than half, is devoted to digital computers starting with basic circuits, followed by control and general organization and storage systems. The basic circuits include the simple two-state circuit, the various forms of gates and an adder. The design and use of a shifting register are also described. In the chapter devoted to control and general organization, the manner in which the instructions held in the store are selected, interpreted and obeyed is explained. The emphasis is on serial machines, and a scheme for a hypothetical computer using delay line stores is built up. Certain of the terms differ from those used in normal computer parlance, but these are none the less suitably descriptive.

A brief survey of storage systems is given which, in common with the rest of the book, is well illustrated by some good plates. A wide variety of digital computer equipments is described, including input and output mechanisms which are used respectively for feeding information into the machine and for obtaining results from it. The applications of digital computers are discussed only in general terms, with particular emphasis on applications to commerce. Mention is made of machine translation of languages and computer-controlled machine tools. The book concludes with an interesting appendix on business computer running costs.

This book will be of interest to scientists and technicians wishing to obtain a general knowledge of analogue and digital computers, but with the possible exceptions of certain sections on digital computers, the treatment is too brief to be of great value to those wishing to specialize in the subject.

R. L. GRIMSDALE

McCARTHYISM

The Torment of Secrecy

The Background and Consequences of American Security Policies. By Prof. Edward A. Shils. (Heinemann Books on Sociology.) Pp. 238. (London: William Heinemann, Ltd., 1956.) 15*s*. net.

THIS book analyses in considerable detail the social and psychological background of McCarthyism. It happened to be just after I had read it that I heard that the Canadian Ambassador in Cairo had committed suicide, apparently as a result of some evidence bandied about in a United States Senate Committee. Although McCarthy was, before his recent death, more or less discredited, the results of his work linger on. Fortunately, there are many signs of relaxation. Though this is only a relatively minor matter, it may be interesting to prospective British visitors to scientific conferences to know that it has become very much easier to get a visa.

The book is not easy reading to the uninitiated. The famous cases—the Hiss case, the Fuchs case, the Oppenheimer case and many others—are constantly referred to, but are not actually described. The reader not well informed about these cases would be somewhat at a loss. Most of the writing refers, quite

naturally, to the American scene. The mentality of McCarthyism is analysed in terms of various American historical movements, and it is shown how the isolationist type of outlook, when confronted with the challenge of communism, was led to support an extreme form of anti-intellectualism involving considerable loss of liberty and often unfair treatment for those individuals unlucky or unwise enough to get involved in alleged or real security cases. The mentality of the intellectual of the 30's who became involved in communism out of naïvety, largely because he distrusted his local politics and politicians, is also analysed.

All this may seem rather remote from the British point of view, and the book is certainly not to be recommended except to those of us who have definite interests in the American way of life. But some space is given to the British background and the very different attitude of mind about security to which it has led. While the Americans were worrying individuals like Owen Lattimore, who seems to have been nothing more than foolish at worst, our system was allowing such obvious culprits as Burgess and Maclean to make a clear get-away.

Prof. Shils is certainly no fellow-traveller, and his book is a plea for common sense. It is unfortunate that he does not do much to elaborate any measures which might help to safeguard liberties without jeopardizing reasonable security of national secrets. But one can hope that this and similar publications will help to educate the mind of the public about these matters.

H. W. B. Skinner

COMBUSTION IN HIGH-SPEED FLIGHT

Combustion Processes

Edited by B. Lewis, R. N. Pease and H. S. Taylor. (High Speed Aerodynamics and Jet Propulsion, Vol. 2.) Pp. xv+662. (London: Oxford University Press, 1956.) 84*s*. net.

HAD there been a Rip van Winkle among pre-war combustion experts, it would be most interesting to-day to observe his reactions after a sleep of a mere twenty years duration. He would surely be even more confounded and confused than was his legendary original. Just as the ultra- and electron-microscopes have enabled man to probe more deeply into the fundamental mysteries of solid matter, so too in the field of combustion the application of many novel and varied techniques, accelerated by a major war, have combined to transform completely both the range and minutiæ of the subject.

"Combustion Processes" is the second of a series of works to be published by the Board of Editors of the Aeronautics Publications Programme at Princeton University. The project has the active support and encouragement of many industrial and research organizations. Under the chairmanship of Theodore von Kármán, and the present general editor, Joseph V. Charyk, the Board aims to treat comprehensively the basic principles and problems of aerodynamics and propulsion as applied to high-speed flight.

The present editors are fortunate in having the services of a galaxy of experts in the branches of technology discussed; there are indeed so many that it could not be other than invidious to single out individuals for mention in a short review. It is perhaps due to the large number of individual authors involved that the system of classification of subject-matter into parts, sections and chapters is not all that might be desired, but to emphasize unduly a minor criticism of this nature would be carping in the extreme. A more pertinent complaint might be that insufficient space is devoted to the practical applications of the theoretical and experimental studies detailed. Omissions on this score tend to render the work somewhat less attractive to students and to newcomers to the field, since, to them, the events or situations necessitating the exhaustive treatment of a given topic may not be immediately apparent. Nevertheless, as a detailed exposition of the present state of knowledge of combustion in the sphere for which it is intended the work will be of great value.

The first third of the subject-matter covers the basic tools of thermodynamics and chemical kinetics. Part 1, on thermodynamics, contains a useful section on computational methods; Part 2, on chemical kinetics, includes such topics as reactions at surfaces, fast reactions and non-equilibrium conditions, as well as detailed discussion of a selection of specific reactions, including the oxidation of paraffin hydrocarbons.

Further sections are devoted to the propagation of flame in gases, the combustion of liquids and solids and detonation processes. Gaseous combustion is exhaustively treated: appropriate sections deal with combustion wave theory in both turbulent and non-turbulent explosive mixtures as well as diffusion flames. The latter includes a discussion of unmixedness which gives rise to a lag between the entrainment of the combustion air and its reaction with the fuel.

Liquid and solid fuels are more than adequately treated. The section on liquid fuels follows the now almost classic procedure of breakdown into the individual processes of atomization, mixing, evaporation and combustion, and that on solid fuels emphasizes the obvious points of similarity and difference between the combustion of solid particles and liquid droplets. The latter section of necessity illustrates many of its arguments by reference to the combustion of carbon, but much recent information bearing on the possible use of metals as fuel is also given. Aware of the paucity of available data in this latter, comparatively unexplored field of research, the authors have shown some ingenuity in pointing to the application of work in such related fields as corrosion and low-temperature oxidation. They have rightly stressed the importance of factors governing ignition. Later chapters, dealing with liquid and solid propellants, repeat the useful technique of an earlier section: generalized treatments are followed by a discussion of the performance of selected propellant systems.

The reader of the last two sections, covering detonation and energy production by nuclear reactions, might be forgiven if he feels that, excellent as are the treatments of these topics, the latter, and, to a less extent, the former, are somewhat out of place in a treatise on combustion. However, this is a question which should, perhaps, be judged in relation to the series as a whole. To date, four of the projected twelve volumes of the series have been published. If the existing standards are maintained, workers in fields allied to modern flight propulsion, as well as many others, will eagerly await the appearance of the remainder.

C. Hulse

MEASUREMENT OF IONIZING RADIATIONS IN MEDICINE AND BIOLOGY

Radiation Dosimetry

Edited by Gerald J. Hine and Gordon L. Brownell. Pp. xiv+932. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1956.) 22 dollars; 157*s*.

THE scope of this book is at the same time both narrower and wider than its title suggests. It is narrower in that the book deals only with ionizing radiations (including neutrons because the secondary radiations produce ionization) and these chiefly from a biological and medical point of view. But at the same time, not only is measurement of radiation included, but also some space is given to the production of radiation, its biological action and some of the technical aspects of the medical applications. The general reader might well feel a little surprised at finding the dosimetry of ionizing radiations to be such a complicated subject requiring such a large volume as this for its exposition. The essential idea of dose as the energy dissipated locally at a point in a medium seems so simple. But it should be remembered that it was not until 1953 that such a unit of dose, the rad (100 ergs per gram), was finally agreed and adopted internationally. The history of dose units in the preceding fifty-odd years is one of practical compromises imposed by limitations of the available techniques of measurement. The earlier workers knew what they wanted but the ideal was unattainable. The amounts of energy absorbed in a medium were generally far too small for successful direct measurement. Hence the recourse to measurement of air ionization and the emergence of the röntgen as a unit which did duty fairly well as a measure of dose and of exposure. Even to-day, the ionization method of dose measurement, based on the Bragg–Gray theory, remains pre-eminent, but even here finality has not yet been reached: witness the uncertainty in this volume as to the precise numerical relation between röntgen and rad.

There are now, however, several other practicable methods of measuring radiation dose, developed under the stimulus of the new discoveries in atomic energy. A need existed for a collected account of all the available methods, and hence the present book has been written. It is the work of well-known experts from both sides of the Atlantic, who have been responsible either singly or in groups for one or more of its eighteen chapters. The editors have found a very satisfactory answer to what must have been a difficult decision by making each chapter largely complete in itself. Inevitably, during a complete perusal of the book some repetition is apparent—Bethe's equation for rate of energy loss seems to appear on countless occasions—but undoubtedly this plan makes the book more convenient for normal use.

There are three main sections in the book. The first, about one-sixth of the total, gives an admirable summary of fundamental principles of dosimetry. It also includes a very condensed summary of the general biological effects of radiation, but it is questionable whether this serves any useful purpose in a book on dosimetry. The remainder of the book is divided about equally between a section on instrumentation and one on applications, and constitutes the book's main importance, for there is so much here that is new. All the various techniques are critically reviewed and the latest developments dealt with fully. At the end of each chapter there is a comprehensive and up-to-date bibliography. The general level of the contributions is very high, with a gratifying freedom from errors and half-truths. The standard of production of the book is superb, the figures and their arrangement are excellent, likewise the index, and the proof-reading has been remarkably thorough. This book is a very significant contribution to a subject of increasing importance and all concerned in it deserve thanks.

G. J. NEARY

THE METAZOAN PARASITES OF ANIMALS

Mönnig's Veterinary Helminthology and Entomology

Fourth edition by Dr. Geoffrey Lapage. Pp. xvi+512+24 plates. (London: Baillière, Tindall and Cox, Ltd., 1956.) 42*s*. net.

THIS new edition of Mönnig's standard text-book has been eagerly awaited, as it is nine years since the third edition appeared and much information on animal parasites has come to light during that time.

It is obvious that Dr. Lapage has had the interest of both student and teacher at heart, for he has endeavoured, wherever possible, to simplify the classification and recognition of the various parasites, particularly in the section on arthropods. Instead of footnotes, a general bibliography with references up to 1956 is provided at the end. The original text figures have been retained and nineteen excellent photographs added. The plates showing the eggs of worm parasites are now on art paper, and these, together with the section on technique and diagnosis, have been transferred to the end of the book. These egg plates might be improved further by including diagrams of larvæ which are passed out in the fæces and of the infective larvæ.

As in the former editions, this book is divided into four sections. Section 1 has been completely rewritten and extended by several pages and deals with types of parasitism, typical life-histories, effects of parasitic life on the parasites and on their hosts, and the resistance by the hosts to parasites. Section 2, on helminths, has been extended by twenty-six pages and revised with the assistance of Dr. Mönnig himself. Four genera and thirteen species have been added, and life-histories, treatments and control measures have been brought up to date. Considering the growing importance of *Nematodirus battus*, one would have liked more information on its morphology and a drawing of the egg included in the egg plate for sheep.

It is to Section 3, on arthropod parasites, that Dr. Lapage has given his particular attention. Much of it has been rewritten and re-classified, more than thirty species added and names altered where necessary to conform with modern nomenclature. Control measures also have been revised, though the strength of the D.D.T. dust given on p. 398 for the control of lice in cattle seems rather too weak to be effective. Section 4 deals with technique and diagnosis and now includes the interpretation of worm egg counts, additional methods for fixing and storing trematodes,

the making of permanent preparations of fleas, mites and insects and the collection and examination of skin scrapings.

In a book of this quality it may appear ungracious to refer to any errors, of which there are remarkably few, but the description of Olsen's method for estimating the number of eggs of *Fasciola hepatica* per gram of sheep fæces requires correcting, also the host parasite list needs further revision to conform with all the changes in the new text.

This edition will, without doubt, enhance the reputation of Mönnig's book and both the author and the publishers are to be congratulated on their achievement. They have rejuvenated it, yet preserved all the excellent qualities of the original and provided a text-book which will be welcomed by all those interested in animal parasites.

F. St. G. Sleith

PLANT HUNTING IN EARLY AMERICA

Edward Palmer

Plant Explorer of the American West. By Rogers McVaugh. Pp. xviii+430. (Norman, Oklahoma: University of Oklahoma Press, 1956.) 6 dollars.

DR. EDWARD PALMER was born about 1831 in Norfolk and emigrated to America in 1849. He became famous during his lifetime as an explorer and botanist, and remains the most important early collector of botanical material in the southern United States and Mexico. His collecting career extended over more than fifty years. He made more than twenty thousand gatherings of plants, and sets of them were widely distributed in Europe as well as in America. Specimens found in herbaria to-day, however, are very frequently incompletely localized and without notes. Prof. McVaugh's book will enable these shortcomings to be remedied.

Palmer's career as an explorer began in 1854 when he sailed to South America with Captain Page on the *Water Witch*, visiting Argentina, Brazil and Paraguay. He next collected plants while on service as an Army surgeon during the Civil War in Colorado, on the frontier in Arizona (1865–67) and in the Indian Territory itself (1868). This must have been a difficult and daring activity, and the account of it makes exciting reading. After this, Palmer's reputation as a collector was established, and, from 1869, he became a professional field-worker, mainly financing himself from the sale of specimens. He usually travelled alone to parts of the United States, branching off from the stage-lines by joining pack-trains or riding with a mail-carrier as his guide. As civilization spread, he moved ahead: his earlier trips were to Colorado, Utah, Arizona and California with incursions into Lower California; later he went to Mexico proper (notably with Parry in 1878) and Texas; after 1885 he concentrated more and more on Mexico and Lower California. He also visited Florida and the Bahamas (1874) and Cuba (1902). Palmer himself published at least thirty-five papers and many others are directly based upon his collections.

The mass of information in this book is very well arranged. The biographical account (120 pages) is followed by a geographical index (221 pages) in which are given elaborate details of Palmer's localities with local itineraries and dates. A summary of his journeys forms the first appendix and another comprises an annotated list of herbaria which include specimens collected by him. His field notes for Colorado (1861) and the Indian Territory (1868) are published in full. There is an extensive bibliography and an index to persons and institutions mentioned in the text. One of the most useful features of the book for non-American readers is the inclusion of footnotes on many of Palmer's contemporaries. On the other hand, such readers may wish the author had included a general map of Palmer's routes to supplement the biographical part of the text. Ideally, the geographical index includes precise references to an annotated list of modern maps. The twelve pages of illustrations include photographs of Palmer and of his handwriting.

Prof. McVaugh has produced a masterpiece of comprehensiveness; his fifteen years of work have resulted in an extraordinarily detailed summary of Palmer's botanical life. But not only this, he has written sensitively of the man as well as objectively of his work, and the book, which understandably has many of the characteristics of a catalogue, conveys also the human interest of the hero's unusual character.

John Lewis

SCIENCE AND DETECTION

The Scientific Investigation of Crime

By L. C. Nickolls. Pp. xiii+398. (London: Butterworth and Co. (Publishers), Ltd., 1956.) 50*s*. net.

THIS book by the Director of the Police Laboratory, New Scotland Yard, gives an account of the work of the seven forensic science laboratories in England and Wales, describing, with many examples, the types of investigation undertaken and the equipment and methods employed. It reveals the great progress which has been made, since the first laboratory of the kind was opened at Hendon in 1935, in the taking over by the police forces of the forensic scientific work formerly done by outside experts.

The scientific and technological work involved is, naturally, of great variety, and the methods range from the use of such weapons as X-ray diffraction, infra-red spectrometry and gas chromatography, to the making of plaster casts of footprints. All the subjects are dealt with adequately, and several, which are probably of the greatest general interest, including bloodstains, toxicology and identification of traces of biological material, are given especially thorough treatment. For example, the fifteen pages on wood fragments, with sixty-three excellent micrographs of sections of different timbers, each illustrating one or, at most, two characters of the Chatterton key card, are so good that they would be a most valuable acquisition, not only to all responsible for the identification of timbers, but also to every student of wood technology. Those pages and most of the remainder of the book, except Chapters 10 and 11, would be particularly useful to many educational establishments, research laboratories and individuals if they were made available as reprints. The subjects of those two chapters and, in particular, the unavoidably sordid examples given in Chapter 10, would appear to render the publication, as a whole, unsuitable for such general circulation.

The book is well produced, with good illustrations and a very full and useful bibliography at the end of each chapter.

H. I. Matthews

Proceedings of the First International Photobiological Congress

(4th International Light Congress), Amsterdam, August 23–28, 1954. Pp. 472. (Wageningen: H. Veenman en Zonen.) 61*s.*; 8.50 dollars; 3,100 French francs; 37.50 Swiss francs; 36 D.M.

PHOTOBIOLOGY covers a multitude of complicated and fascinating subjects: photosynthesis, vision, photoperiodism in plants and animals, the erythemal action of ultra-violet on the skin, and many others. This width of scope might at first sight appear to be a disadvantage, yet the seeming heterogeneity of these topics does in fact give an opportunity for fruitful comparative studies when, as here, they are investigated from a fundamental point of view, based on photochemistry and general physiology. The quantum theory forms a link throughout the whole field, while technical methods of producing and measuring radiation are of common interest to all photobiologists.

The first International Congress of Photobiology of which this volume forms the published Proceedings consisted largely of three symposia and three sections. The subjects of the symposia were photoperiodism, the effect of non-ionizing radiations on the genetic elements of cells, and the effect of the same radiations on the skin. The sections dealt with biological and medical problems, and with the physics, chemistry and climatology of non-ionizing radiation. Two hundred papers of various lengths were presented. Many of them are published only in abstract form, but there are valuable summaries of the discussions which followed, and critical reports by the chairmen of symposia and sections. The Proceedings are beautifully produced with many illustrations in line and half-tone. There is an author-index. Both the participants to the Congress and others interested in photobiological problems will find this volume a mine of valuable and often unexpected information, ranging from measurements of the ultra-violet penetrating into the sea to discussions of the very complex influences which induce the flowering of plants.

M. H. PIRENNE

Progress in Nuclear Energy

Series 2: Reactors. Edited by R. A. Charpie, D. J. Hughes, D. J. Littler and M. Trocheris. Vol. 1. Pp. x+492. (London: Pergamon Press, Ltd., 1956.) £5 net.

THE first five chapters are devoted to research reactors. Chapters 1, 4 and 5 are reviews, written especially for the volume, describing the functions of the various reactors and giving in some detail their performance and characteristics. Chapter 4 is particularly valuable in containing details of the experimental work carried out with the European reactors. Chapters 2 and 3 are the American and Russian papers presented at the Geneva conference in 1955 and rewritten for the book. Five important Geneva papers on power reactors make up the second part of the book. It is valuable to have these grouped together, but an improvement would have been achieved by including, at the beginning of this section, at least one integrating paper reviewing the claims and potentialities of the several systems described in chapters 6 to 10.

A critical discussion of the relative merits and possible difficulties of the various power reactor systems, coupled with a broad indication of the direction and extent of research and development required to establish each system as a competitive power station, would fulfil a real need. The last chapter is a valuable review of the Geneva paper on fast power reactors. The catalogue of reactors, which completes the book, is very interesting and will be greatly used. It is hoped that the editors will be able to make some attempt to keep the catalogue complete and up to date for at least the next few years. Adequate line diagrams have been included, although some of the photographs of reactor installation could have been omitted. In general, the volume is well produced and is a worthwhile addition to most science libraries.

D. R. CHICK

Small-Angle Scattering of X-rays

By Prof. André Guinier and Gérard Fournet. Followed by a bibliography by Kenneth L. Yudowitch. (Translated by Christopher B. Walker.) (Structure of Matter Series.) Pp. xi+268. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1955.) 60*s.* net.

THIS very comprehensive book, by two recognized authorities, should prove especially valuable to anyone actively interested in the applications of small-angle X-ray scattering. The main criticism of the book is that some chapters, though not all, are very mathematical, but this is to some extent inevitable due to the nature of the subject. In the first part of the book, the general theory of small-angle scattering is developed, its dependence on such factors as the shape, the dispersion and the distribution of sizes of the scattering particles being considered. This is followed by a section on experimental equipment which should be particularly useful to anyone contemplating work in this field. The principles underlying the design of slit systems and bent-crystal monochromators are worked out, and many experimental arrangements are described in detail, the discussion of such points as slit dimensions and exposure times being severely practical. The authors then proceed to what they call the real problem, namely, the interpretation of the experimental results in the light of the general theory developed earlier. The book ends with a critical discussion of much of the experimental work already published on small-angle X-ray scattering, and considers possible future applications of these techniques. The classified bibliography includes more than five hundred references.

I. G. EDMUNDS

Report of the Conference on Recent Developments in Cloud-Chamber and Associated Techniques

Comprising collected papers of the conference held under the joint auspices of the Physical Society of London and University College, London, in March 1955. Edited by N. Morris and M. J. B. Duff. Pp. vi+227. (London: University College, 1956. Distributed by Pergamon Press, London.) 30*s.*

THE spectacular developments that have taken place in recent years in means of rendering visible the tracks of individual charged particles prompted the decision of Prof. H. S. W. Massey to organize a conference at University College, London, during March 1955 to discuss these techniques. The papers delivered at this conference, which have now been collected and published, provide a comprehensive account of these developments.

In the organization of the conference the term "Associated Techniques" was interpreted very broadly. Articles in this volume deal with the diffusion cham-

ber, the multiplate and high-pressure cloud chambers and the hydrocarbon and liquid hydrogen bubble chambers in addition to the more conventional types of Wilson cloud chamber. They cover not only questions of chamber design but also problems raised in the interpretation of the photographs, track distortion, selection systems, and so on. Of particular interest is the discussion of methods used for increasing the recycling rate of Wilson chambers by using techniques of fast recompression or overcompression.

Attractively reproduced, using the 'Vari-type' process, there is no doubt that this report will, for a long time to come, continue to be of great value to all research workers using these methods of particle detection.

Remington's Practice of Pharmacy

Edited by Eric W. Martin and E. Fullerton Cook. Eleventh edition. Pp. xii+1707. (Easton, Penn.: The Mack Publishing Company, 1956.) 18 dollars.

THIS large volume is primarily a text-book and reference guide for pharmacists, including students, retail and hospital pharmacists, lecturers, manufacturers and executives. It deals not only with scientific problems but also with questions of administration and legal matters. Five years have elapsed since the last edition appeared and the book has been brought up to date by a team of more than two hundred assistant editors and contributors. Nearly a thousand pages are devoted to the discussion of individual drugs; Dr. C. T. Van Meter is responsible for the chemistry of this section and Dr. Louis S. Goodman is responsible for the pharmacology. The result is that a vast amount of reliable information about American drugs is here available for reference. The official drugs used in Britain are generally the same, though they do not always have the same names, but unfortunately the unofficial drugs used in Britain are often different and are not included. There are sections on chromatography, statistics, biological testing and various other topics.

J. H. Gaddum

A Dictionary of Terms in Pharmacognosy and Other Divisions of Economic Botany

By Prof. George Macdonald Hocking. Pp. xxv+284. (Springfield, Ill.: Charles C. Thomas; Oxford: Blackwell Scientific Publications, 1955.) 70*s*.

THE title of this book is a little misleading as the contents cover a much wider field than it suggests. Pharmacognosy is the study of those plants and animals and their products which are used as sources of medicinal and pharmaceutical substances. Like other sciences, it has its own technical terms, though most of these are derived from the biological sciences. While this dictionary does define these terms, it also gives concise information on the sources, active principles, uses, and other details of a large variety of materials. Some of these are mineral in origin, some are synthetic compounds, and some are spices and foods, and would not normally be included under pharmacognosy. The book is therefore a compendium of information on the terms and materials likely to be encountered in pharmacy, economic botany, and the foods and drugs trade. The names and terms are arranged alphabetically and include such diverse items as Bourbon whisky, boysenberries, lysergic acid and streptodornase; thixotropic gel, tracheid and tolerance; gamma-globulin, garbling and gamopetaly. Each item is defined and, where appropriate, the names of the genus and species are given, with a brief description and interesting historical data. Another useful feature is the inclusion and definition of many vernacular and popular names for commodities. There are eight appendixes which include a bibliography, a glossary of terms used in therapeutics and botany and a list of plants yielding rubber. This dictionary is therefore a very useful reference book for anyone connected with economic botanical products and related substances.

J. W. Fairbairn

Proceedings of the Third International Congress on High-Speed Photography

Held under the auspices of the Department of Scientific and Industrial Research in London, 10th–15th September 1956. Edited by R. B. Collins. Pp. xvi+417. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1957.) 70*s*.; 13 dollars.

SINCE 1952, international congresses on high-speed photography have become biennial events because of continued advances and applications of its technology. The third congress took place in London during September 1956 and a full report was presented in *Nature* by Dr. J. S. Courtney-Pratt (178, 1440; 1956). The proceedings of this congress, which have now been published, indicate the international character of the art. Apart from twenty-two British contributions, papers were received from France (13), United States (12), Germany (5), Japan (3), Switzerland (3), U.S.S.R. (2) and Holland (1). The ever-growing importance of high-speed photography as a research tool is evidenced by the fact that more than one-third of the papers deal with the application of techniques to such diverse studies as aerodynamics, ballistics, biology, combustion, hydrodynamics, and general industrial problems. Rapid progress in the development of new techniques and in the improvement of old ones is leading to an ever-increasing complexity of design and possible wastage of effort, and the stage has been reached for critical assessments to be made by the leading authorities of each field.

The editor and publishers are to be congratulated for the speed with which the volume has been produced. It seems advisable, however, for future organizing committees to consider standardization of the published proceedings. For example, the size of the volumes of the first, second and third proceedings have been 9 in. × 6 in., 11½ in. × 8½ in. and 10 in. × 6 in., respectively, while the corresponding languages were English, English/French/German, and English.

N. Dombrowski

Chemistry of Carbon Compounds

A Modern Comprehensive Treatise. Edited by Dr. E. H. Rodd. Vol. 3, Part B: Aromatic Compounds. Pp. xx+687–1669. (Amsterdam: Elsevier Publishing Company; London: Cleaver-Hume Press, Ltd., 1956.) £8 10*s*.

THE present volume of this series continues and completes the description of the benzenoid class of organic compounds. Again the choice of compounds in this vast field has had to be discreetly limited, but again a most useful source book has resulted. As well as describing recent work on the more familiar benzenoid systems, the volume also deals with the new aromatic systems involving seven- and five-membered carbocyclic rings. As usual, the index is excellent.

R. A. Raphael

NON-CONSERVATION OF PARITY*

By Prof. B. BLEANEY, F.R.S.

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ONE of the puzzling features of meson physics is the relation between the θ- and τ-mesons. The most accurate experiments indicate that the lifetimes of these two particles are identical (approximately 10^{-8} sec.) and that they have the same mass (approximately 970 times that of the electron). Thus they would appear to be identical particles, but the modes of decay are different: in one case two, and in the other case three, pi-mesons are produced. The difficulty in taking these to be alternate methods of decay of the same particle is that the set of decay products has even parity in one case and odd parity in the other. Thus if parity is conserved in the decay, the θ- and τ-mesons cannot be identical particles, since they have opposite parity.

This difficulty led Profs. T. D. Lee, of Columbia University, and C. N. Yang, of the Institute for Advanced Study, Princeton University, to examine the evidence[1] for the 'law' of conservation of parity. They found there was good evidence for the validity of this law in the so-called 'strong interactions', and in processes where electromagnetic radiation is emitted. On the other hand, such evidence was missing in the cases of 'weak interactions'—the decay of mesons and hyperons, and processes such as beta-decay. They therefore proposed a number of experiments in which the law of conservation of parity might be tested; two such types of experiment have now been carried out. Each involves the direction of emission of the products of the decay of radioactive particles relative to the orientation of the intrinsic angular momentum or spin of these particles. The connexion between this phenomenon and the conservation of parity can be seen as follows.

Let us assume that we are dealing with particles spinning about a particular direction in space which we take to be the z-axis. Then the particles have a constant component of angular momentum about the z-axis; on an elementary basis we can say that a portion ∂m of the particle which has co-ordinates x, y and velocity components $\partial x/\partial t$, $\partial y/\partial t$ relative to the centre of mass carries angular momentum ∂G_z about the z-axis, where:

$$\partial G_z = \partial m\left(x\frac{\partial y}{\partial t} - y\frac{\partial x}{\partial t}\right)$$

Now the parity operation may be defined as follows: if we invert our co-ordinate system through the origin so that the spatial co-ordinates x, y, z become $-x$, $-y$, $-z$, then a quantity which is unchanged in sign has 'even parity', while a quantity which changes sign has 'odd parity'. It is readily seen that ∂G_z has even parity, since it involves only products of two spatial co-ordinates; both these change sign in the inversion, but their product does not. Now let the particle be radioactive, emitting rays in various directions. The direction of emission is characterized by the linear momentum of the ray, with components p_x, p_y, p_z (or by the velocity components $(\partial x/\partial t)$, $(\partial y/\partial t)$, $(\partial z/\partial t)$). It is readily seen that the linear momentum of the ray is a quantity with odd parity, since it changes sign on inversion of the co-ordinates. If, however, in the centre of mass system of the radioactive particle, as many particles are emitted with momentum components p_x, p_y, p_z as are emitted with components $-p_x$, $-p_y$, $-p_z$, then the parity of the system of decay products will be even, since we cannot distinguish between the different particles: all we can do is to measure the number of such particles emitted in a given direction. In this case parity is conserved in the decay. On the other hand, if more particles are emitted with components p_x, p_y, p_z than with components $-p_x$, $-p_y$, $-p_z$, then the system of decay products will have a certain amount of odd parity, and parity is not conserved. Mathematically, we can express the angular distribution of decay products by the intensity law,

$$I(\theta)\mathrm{d}\theta = (\text{constant})(1+\alpha\cos\theta)\sin\theta\,\mathrm{d}\theta$$

where $I(\theta)\mathrm{d}\theta$ is the number of particles emitted in an elementary cone of directions making an angle θ with the z-axis. If parity is conserved, the parameter α is zero, and $I(\theta)\mathrm{d}\theta$ remains unchanged during inversion of the co-ordinates (since we are dealing with a system with symmetry about the z-axis, inversion has the same effect as a reflexion in the plane $z=0$; that is, it changes θ into $\pi-\theta$). If α is not zero, then more particles are being emitted above the plane $z=0$ than below it, or vice versa. In particular, if we measure the intensities I_0, I_π along the positive and negative directions of the z-axis (that is, at $\theta=0$ and $\theta=\pi$), then the value of α is given by:

$$\alpha = \frac{I_0 - I_\pi}{I_0 + I_\pi}$$

The first successful experiment[2] to determine the value of α was carried out at the U.S. Bureau of Standards by Messrs. E. Ambler, R. W. Hayward, D. D. Hoppes and R. P. Hudson, in collaboration with Mrs. C. S. Wu, of Columbia University. Essentially, the experiment involved obtaining a set of polarized nuclei of the radioactive isotope cobalt-60, which decays to nickel-60 emitting beta-rays and gamma-rays. The polarization of the nuclei is obtained by taking advantage of the fact that the nuclei have magnetic dipole moments parallel to their spin angular momenta. If they are immersed in a magnetic field of about 100,000 oersteds at a temperature of about 0·01° K., then the nuclear magnets will set parallel to the magnetic field because the thermal agitation at this temperature is insuffi-

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cient to supply the energy required to turn them anti-parallel to the field. The high magnetic field is supplied, not by an external magnet, but by the magnetic moments of the electrons in the cobalt ions. If a small external field (say a few hundred œrsteds) is applied, the electronic magnets are oriented parallel to this field, and hence so also are the very large fields which they produce at the nucleus, a trick suggested[3] independently by Prof. C. J. Gorter and Dr. M. E. Rose in 1948. That this method successfully polarizes the nuclei had previously been shown[4] by observing the anisotropic emission of gamma-rays (more are emitted parallel or anti-parallel to the direction of polarization than are emitted in the equatorial plane); but in gamma-ray emission parity is conserved and equal numbers are emitted in the up and down directions. Because of the small penetrating power of the beta-rays, they had to be detected by a counter placed inside the cryostat, and the radioactive cobalt had to be in a thin layer on the surface of the crystal (cerium magnesium (cobalt) nitrate), which is cooled to about 0·01° K. by the method of adiabatic demagnetization. The counter detected beta-rays emitted parallel or anti-parallel to the axis of polarization of the cobalt-60 nuclei, which could be reversed by reversal of the external field. It was found that the beta-rays were preferentially emitted in the direction opposite to that in which the nuclear spins were pointing; the asymmetry was so great as to suggest that the parameter α might approach -1 ($I_e/I_\pi \to 0$) if the nuclei were completely polarized.

Independent confirmation of non-conservation of parity has been obtained in an experiment[5] carried out at the Kamerlingh Onnes Laboratory, Leyden, in collaboration with the University of Groningen. The method employed was similar, but the emission of positive electrons from the radioactive nucleus cobalt-58 was observed. In this case the positive electrons are emitted preferentially in the same direction as the nuclear spins were pointing and the value of α approached the maximum value possible for this example of beta-decay.

The second experiment is similar in nature but uses a quite different type of system; it was carried out[6] by Messrs. R. L. Garwin, L. M. Lederman and M. Weinrich at the Nevis Cyclotron Laboratory of Columbia University. It was pointed out by Lee and Yang that if parity is not conserved in the successive reactions:

$$\pi^+ \to \mu^+ + \nu$$
$$\mu^+ \to e^+ + 2\nu$$

the spin of the mu-meson will be polarized along its direction of motion, and in consequence there should be a preferential emission of positive electrons parallel to this direction. The large effects observed in the cobalt-60 experiment suggested that this effect should be readily detectable. Positive mu-mesons formed by the decay in flight of positive pi-mesons were filtered out from the latter, and brought to rest in a carbon target. The passage of mu-mesons through the filter was detected by a pair of counters (1,2) feeding a coincidence circuit. The subsequent decay gives positive electrons which are detected by a pair of counters (3,4) arranged as a telescope to observe only those emitted at a given angle, again using coincidence methods and a time delay appropriate to the mean life (about 2·2 μsec.) of the mu-mesons. Instead of rotating the telescope with respect to the direction of arrival of the mu-mesons at the target, and hence also with respect to their direction of polarization, the telescope was left fixed and the direction of polarization rotated by applying a magnetic field to the target. This has the double advantage of giving a fixed geometry and determining the magnetogyric ratio (the ratio of the magnetic moment to the angular momentum) of the mu-meson, since the angle through which the polarization rotates in a given time depends on the product of this ratio and the size of the magnetic field. The experiment showed that again the asymmetry of emission of electrons approached its maximum possible value, and also that (within the experimental error of ±5 per cent) the magnetogyric ratio has the same 'Dirac particle' value 2·00 in units of $(e/2mc)$ as the electron. This value shows that the spin-momentum of the mu-meson remains closely parallel to its linear momentum when travelling through a magnetic field, since both are turned through the same angle, a result independently confirmed during the extraction of the mesons through the fringing field of the cyclotron magnet. This experiment has been repeated at the University of Liverpool by Prof. J. M. Cassels and his colleagues, who find the value 2·008 ± 0·014; at Columbia University it has been refined by the use of a magnetic resonance technique, which yields the value 2·0064 ± 0·005.

The asymmetry has been observed independently at the University of Chicago[7], where since October 1956 nuclear emulsion pellicles have been regularly exposed to the π^+ beam of the synchro-cyclotron. More than 1,300 decays of pi- to mu-mesons to beta-rays have been observed, with a considerable predominance of emission of the latter in the backward direction. These experiments give only a lower limit to the effect, owing to the possibility of the formation of 'muonium' (a hydrogen-like atom with a μ^+ meson as nucleus and one electron), a process in which some of the μ^+ mesons will lose their spin orientation.

These experiments and others now in progress test several principles (invariance under charge conjugation and time reversal) in addition to conservation of parity. An important result is that they suggest it may be possible to use a two-component theory of the neutrino, in which the spin of the neutrino (ν) is always parallel to its direction of motion, while that of its conjugate particle the antineutrino ($\bar{\nu}$) is antiparallel; thus one advances like a right-handed screw, and the other as a left-handed screw. Such a theory can only hold if the rest mass of the neutrino is zero, so that it always travels with the velocity of light. (It does not provide a direct solution of the θ–τ puzzle, since no neutrinos are involved in their decay.) These and other consequences are discussed in a subsequent paper of Lee and Yang[8], and were independently suggested by Landau[9] before the experimental results were known.

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[8] Lee, T. D., and Yang, C. N., *Phys. Rev.*, **105**, 1671 (1957).
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WILLIAM HARVEY (1578–1657)

By Prof. F. J. COLE, F.R.S.

HARVEY, who discovered the circulation of the blood, was born on April 1, 1578, at Folkestone. The family consisted of seven sons and two daughters, of whom Harvey was the eldest of the sons and the first born of his father's second wife. He died on June 3, 1657, at Roehampton, Surrey, in the house of his brother Eliab. The only contemporary details we have of his personality we owe to John Aubrey's short "Life", not printed until 1813. Aubrey was forty-eight years younger than Harvey, and only thirty-one when Harvey died. The accuracy of his narrative has been seriously questioned, and the scrupulous politeness practised by Harvey in his controversial writings leads us to a better understanding of his character.

Apart from the tercentenary celebrations of Harvey's death to be held this year, the College of Physicians had already organized two others. The first of these was held in 1878, in which T. H. Huxley played an important part. The second, in 1928, devoted to the tercentenary of the discovery of the circulation of the blood, was attended by delegates from all parts of the world, who were received by King George V. Addresses were delivered by Sherrington, Chauffard and Keibel.

Harvey's discovery did not create the stir which it deserved. It was almost ignored, and even in some universities it was claimed that it had made no change in the practice of physic. Its supporters were referred to in derision as "our modern circulators", or "quacks" as that expression was at the time translated. One of its earliest supporters was the wealthy antiquary and bibliophile Peiresc, who removed the title page from his copy of the first edition of 1628 and added it to his collection of title pages: this mutilated copy was sold in the United States recently for £742. Peiresc regarded it as an "excellent book" and believed that arteries and veins were connected up by "secret anastomoses". Sir Thomas Browne, in 1658, remarks that Harvey, though without issue, "discoursed . . . excellently on generation". He even considered that the publication of Harvey's work was more important than the discovery of America. Boyle, in 1663, tells us that Harvey admitted to him that it was the structure of the valves of the heart and of the veins which first pointed to the "circular motion of the blood". In the University of Bologna it was proposed that medical students on graduating be asked to swear that the doctrines of "Hippocrates", Aristotle and Galen were not to be overthrown by any person whatever. Harvey himself claimed that no physician who had passed the age of forty accepted the circulation. John Aubrey quotes him as saying that after his book was published "he fell mightily in his practice, and 'twas believed by the vulgar that he was crackbrained; and all physicians were against his opinion". Before he died, however, his work was almost universally accepted, so that Hobbes, who died in 1679, said that Harvey was "perhaps the only man that ever lived to see his own doctrine established in his lifetime". Harvey had been physician to Lord Bacon, but owed nothing to his philosophy, which he wrote, according to Aubrey, "like a Lord Chancellor". William Hunter considered that when the valves of the veins had been discovered the circulation might easily have been established by any person of common abilities. Osler also expressed astonishment that Fabricius did not discover the circulation; but in this case as in so many others the simplicity of the discovery obscured its originality. The fatal error made by Fabricius was the assumption that the valves of the veins acted as dams to the gravitational flow of the blood. In France the opposition of Riolan, a man of great learning and experience, prevailed until Louis XIV officially endorsed the new discoveries in 1673.

There can be no question that Harvey was a profound Peripatetic. "Foremost of all among the ancients," he says, "I follow Aristotle; he is my leader." Nevertheless, his injunction to others was to study Nature by way of experiment. On the other hand, it was Bacon's avowed purpose to destroy the supremacy of Aristotle. According to Payne the study of Galen is very important. "It is hard to see how anatomy would have arisen when it did had Galen's works perished." Modern anatomy and physiology began when these works were studied in the original.

Harvey generally refers to himself as an anatomist, and although the term 'physiology' had been introduced before he was writing he was also a physiologist, but had little knowledge of histology. For example, he takes no account of the occurrence of elastic and muscular tissues in the walls of the blood vessels. Occasionally he mentions using a hand lens; but adequate microscopic equipment was not available in his time. He refers frequently to demonstrations before friends of the truth of his discovery, and claims that he was the only observer to oppose tradition and to assert that the blood travelled along a previously unrecognized circular pathway of its own. Erasistratus, in the third century B.C., was the first to believe that the arteries contained air and not blood. This statement was controverted by Galen, Vesalius and Harvey himself, nor did Harvey support the belief that the ventricular septum was perforated so that blood could pass directly from the right ventricle into the left. There are no pores, he says, and it is not possible to demonstrate them. When, however, the pores were finally abandoned, later writers assumed that blood might after all *percolate* through the septum, the absence of pores notwithstanding.

It is important to bear in mind that Harvey's attitude towards anatomy and physiology is that of the *comparative* biologist. He is, in fact, very emphatic on this point, and stresses that many features in human anatomy are readily comprehensible if they are studied from the comparative point of view. Hence his researches include numerous observations on arthropods, molluscs, fishes, amphibians, reptiles, birds and mammals. The heart, he says, is present in almost all animals large or small, and in Chapter V his description of it is simple, clear and convincing. He did not attempt to dissect the small invertebrates, such as insects, owing to the difficulty of obtaining accurate results on types so small. Much vivisection was practised by Harvey, which enabled him to study the nature of the movements of the heart under examination. He also succeeded in massaging the heart of a dove after all its motions had ceased. In eels and some other fishes the heart was found to beat after removal from the body, and even when cut into pieces each piece continued to contract and relax.

The movements of the heart are more easily observed in the lower cold-blooded vertebrates such as small fishes, amphibians and reptiles and also in some of the higher invertebrates such as snails and other molluscs, lobsters and crustaceans. He considers that the "heart proper" includes only the two ventricles, the auricles being simply enlarged veins.

In modern times Harvey's work on the circulation has been extensively criticized. His views on the circulation, he says, are so novel and hitherto unknown as to make him "fear that I may suffer from the ill-will of a few, but dread lest all men turn against me". Most of the argumentative literature has been devoted to an attempt to establish Caesalpinus as the discoverer of the circulation. His name is mentioned once in the 1616 lecture notes but not in the 1628 work. On the whole, leading authorities such as Haller and T. H. Huxley emphatically attribute the discovery to Harvey. The latter states that Caesalpinus added nothing to Columbus and claimed nothing. He did not anticipate Harvey. "The motion of the blood, as a whole, is circular . . . due to the contractions of the walls of the heart." Harvey was completely original on this point. According to Huxley it cannot be said that Servetus, Columbus and Caesalpinus deserve any share of the credit of the discovery. Harvey was not only the first to analyse and synthesize the mechanism by which the circulation is brought about, but he was also the first to attack a physiological problem by quantitative methods, that is, to discuss how much blood is driven out of the heart by each heart-beat and how this is related to the quantity of blood in the whole body. According to Harvey we may assume that the amount of blood extruded by each beat of the heart, which cannot return to the heart because of the barrier set up by the valves, is half an ounce. In half an hour the heart makes at least a thousand beats, from which it follows that five hundred ounces have passed through the heart into the arteries. Such a quantity greatly exceeds the amount of meat and drink consumed within the time specified. Therefore the blood must describe a circle, and of necessity return to the place whence it started, and the contraction of the heart is its sole efficient cause. Other calculations made at the time and since have estimated that *all* the blood in the body passes through the heart about once in four minutes. Harvey's figures have been questioned as an exaggeration, and Descartes, who accepted the circulation, believed that blood returned to the heart "drop by drop". Sherrington, on the other hand, finds that "in violent exercise a volume of blood five times the whole of that within the body may race through the heart each minute".

In 1870, Daremberg introduces an element of ironic humour into the circulation controversy. "I have been singularly disappointed," he says, "to see such an imposing array of citations brought into the service of an indefensible cause, and to learn that of all the ancient and modern writers it is Harvey who has played the *smallest* part in the discovery of the circulation."

It is possible to apply to the claims of Caesalpinus and others who had preceded Harvey a simple acid test. The basic vital fact at the root of the controversy is the existence of one-way traffic only in the blood vessels, with the heart as the ceaseless motive factor. Until we reach the time of Harvey not a single claimant survives the test. Harvey alone does so, and is hence the discoverer of the circulation. It is true that there is in the works of Caesalpinus a passage which assumes that the blood in the arteries is flowing away from the heart and in the veins towards it. On the other hand, there are also assertions that the veins, by a to-and-fro motion, convey blood *to* the tissues. The caval veins, he says, withdraw nutrient blood from the liver and distribute it to all parts of the body for their nourishment, in spite of the venous valves, which are not mentioned. Also he accepts a partial transfusion of blood through the ventricular septum from the right ventricle to the left. Such a writer cannot be allowed to have any knowledge of the Harveian circulation. He could have known of the pulmonary circle which was well described by Columbus in 1559, twelve years before the publication of his own work. Much has been made of the fact that Caesalpinus uses the word *circulatio*. The only other time it appears in classical Latin is by Vitruvius, who describes the orbit of the planet Mercury as a *circulatio*. The term, however, is found also in some contemporary manuscript notes in the Bodleian Library of one of the students of Caesalpinus at Pisa, and here the context indicates that the movement in question is one of up-and-down, and to-and-fro, which is a chemico-physical phenomenon and not Harvey's conception of the circulation. Boyle, when himself about twenty-nine years of age, asked Harvey what had suggested the circulation to his mind, and was told that when he realized that the valves of the veins permitted blood to travel towards the heart but not away from it he had concluded that the motion of the blood must be in a circle. Assuming this incident to have been correctly reported, it must be added that Harvey's conclusion is not necessarily justified by so isolated an experience.

Harvey devotes considerable attention to the structure and physiology of the heart. He understood the functions of the valves and recognized that the heart is a double four-chambered structure including two circles, pulmonary and systemic, and that there is no direct connexion whatever between its right and left portions. What we have, therefore, are two circles and an apparently single four-chambered heart formed by the apposition of right and left two-chambered hearts. The entire vascular system, however, can also be represented in a diagram as a single circle with two separated right and left hearts. Such an arrangement would have pleased Harvey had it occurred to him.

In the lower terrestrial vertebrates Harvey did not discover that the auricle was divided as in the frog, but he gives a very good description of the heart and its function in the higher forms, and observations on the comparative anatomy of the heart are also added. He did not succeed in finding a heart in many invertebrates now known to possess one, and in these cases he believes that the whole body is a heart and nothing but a heart. In insects it is possible with a lens to see a pulsating vessel in their bodies. In Crustacea and snails a contractile vesicle or auricle, as he calls it, can be observed, but no ventricle, which ceases to beat in cold weather. A two-chambered heart and red blood are always present in the lower vertebrates. In the higher types a second or "right" ventricle is added to drive blood only to the lungs, the other or "left" ventricle supplying the whole body except the lungs. The inthrust of blood into the arteries is believed to be the cause of their pulsation.

Ligation experiments play a large and important part in Harvey's methods somewhat late in his life. He did not invent the method, but used it to test and confirm his conclusions. If a vein is tied, the way into the heart is blocked, and the vessel swells up against

the ligature, but in a similar experiment on an artery the way out from the heart to the tissues is now blocked. Hence in an artery the blood is flowing away from the heart and in a vein it is flowing towards the heart. The mistake made by Fabricius was to assume that the function of the valves of the veins in the leg was to facilitate some motion of the blood towards the periphery, whereas Harvey showed that they would prevent any venous blood flowing away from the heart and are hence anti-gravitational.

Harvey attempts to explain, in frogs and reptiles where there are true lungs and only one ventricle in the heart, how the two bloods are kept separate, but his knowledge of those devices which exist to ensure at least a partial separation of the venous and arterial bloods was inadequate for this purpose. The question is not as simple as he supposed, nor was he aware that the auricle is divided in the lower land vertebrates, which would have suggested a modification of his views. He was thus induced to believe that in mammals the fœtal lungs were idle and functionless and hence that there was no pulmonary circulation in embryonic life. This major error has been finally corrected by the experiments of Franklin and Barclay, who have established that the fœtal circulation is in fact vigorous and rapid. Harvey's version, on the other hand, is based almost entirely on the work of his predecessors to which he added only a few observations of his own. Arantius in 1564 had stated that the maternal and fœtal bloods did not mix in the placenta. This was accepted by Harvey but not investigated by him. It was demonstrated experimentally by injections in the eighteenth century. Harvey, however, does not consider that his main thesis is compromised by such minor issues, which he proposes to deal with in a separate treatise. His Chapter VII on the pulmonary circulation in the adult and on the uses of the valves is admirable and convincing, the motion of the blood being continuous, uninterrupted and not reversible. Harvey found no valves in the arteries, and the capillary vessels were discovered in the frog by Malpighi in 1661, four years after the death of Harvey. The optical equipment necessary for the discovery was not available at the time, although in the 70's and 80's of the seventeenth century Leeuwenhoek added considerably to our knowledge of the blood capillaries with the aid of a single bi-convex lens. Harvey, however, does mention certain "capillary veins" which unite to form the factors of the larger veins. This would suggest direct microscopic anastomoses between arteries and veins, in addition to a diffusion of the blood through the "porosities" of the tissues, which he also accepted. In Chapter IX Harvey announces that he is now busy with research into the capillaries.

We are often told that when Harvey left Padua in 1602 the work of Fabricius on the valves of the veins, which was published in 1603, had already begun to simmer in his mind. It did not boil over, however, until fourteen years later, when the discovery is announced in a brief statement in his lecture notes, and another twelve years passed before his book was printed. In this work his first preoccupation is with the pulmonary circulation, which he must have known from the work of Columbus, who is quoted a number of times in the lecture notes of 1616. Having solved the lesser problem he then proceeded to complete the task with his experiments on the systemic circle. He suspected the existence of the blood capillaries but had never observed them, nor was he aware that the blood underwent any reaction during its passage through the lungs, although he knew that it changed in colour.

According to some modern critics "circulation is visualized as a cyclic process of blood regeneration". Blood circulation is the replica of planetary motion and of the zodiac in the animal body. "Circulation assumes the rank of the microcosmic copy of a general cosmological plan." "It is the fundamental symbol and pattern of all life and action in the cosmos" (Pagel). Such circle symbolism reminds us of the transcendentalism which in the nineteenth century seduced even Johannes Müller in his early days.

At the end of Chapter XVI there is a passage dealing with the veins of the intestine which should not be translated as if these vessels were *distributed* to the gut. The verb used is *dissemino* and not *distribuo*, and should be translated *spread out*. The context makes it certain that the blood in these vessels is on its way *to* the heart.

It is not known how many copies of Harvey's book on the circulation of the blood were printed. In 1944, Weil, after careful research, was able to trace the existence of forty-seven copies of the 1628 volume. It is obvious that such a list cannot be complete, and the present writer could add six copies to this list and mention of three others. A good facsimile copy in colour of Harvey's M.D. Padua diploma has also been published.

When Harvey died his body, "lapt in lead" and without any coffin or other covering, was deposited in the vault of the Harvey Chapel in Hempstead Church in Essex. In 1883 it was found that the chapel had reached a shocking state of dilapidation, and was not a fitting resting-place for the remains of Harvey. The Royal College of Physicians, however, restored the chapel and supplied the marble sarcophagus in which the remains are now preserved in the chapel above the vault. The last member of the Harvey family to distinguish himself was Admiral Sir Eliab Harvey (1758–1830), who commanded the *Fighting Téméraire* in the battle of Trafalgar, and whose choleric attack on the Admiralty almost neutralized his great services at sea.

DATES IN HARVEY'S LIFE

1578	Born April 1, Folkestone, Kent.
1588	King's School, Canterbury.
1593	Caius College, Cambridge.
1597	B.A. Cambridge.
1598	Padua. Fabricius.
1600–01	Conciliarius of "English Nation".
1602	Doctor of Physic, Padua.
1602	M.D. Cambridge.
1604	Married daughter of the physician to Queen Elizabeth.
1607	Fellow of College of Physicians.
1609–43	Physician at St. Bartholomew's Hospital.
1613	Censor, College of Physicians.
1615–56	Lumleian Lectures, College of Physicians.
1616	First mention of the circulation of the blood in his lecture at the College of Physicians.
1623	Physician to King James I.
1628	Publication of work on the Circulation of the Blood. Price 6s. 2d.
1630	Travels abroad in France and Spain.
1631	Physician to King Charles I.
1633	Honorary Burgess of the City of Edinburgh.
1635	Report on post-mortem of Thomas Parr, aged 152 years.
1636	Visit to Italy, accompanied by Ent.
1641	Honorary Burgess of Aberdeen.
1642	Harvey's quarters looted and important MSS. lost. M.D. Oxford.
1645–46	Appointed by the King to be Warden of Merton College, Oxford.
1649	Harvey replies to Riolan's attack on the circulation.
1651	Publication of his work on Generation.
1653	First English edition of the "De Motu Cordis".
1657	Died at Roehampton, Surrey, on June 3.
1666	Great Fire of London. Harvey's books and Museum, which had been catalogued in 1660, destroyed.
1881	Bronze statue erected on Folkestone Leas and dedicated to the town by Sir Richard Owen.
1883	Restoration of the Harvey Chapel by the College of Physicians and deposit of Harvey's remains in a marble sarcophagus.

EFFORT-CONTROL THROUGH BARGAINING

By Dr. HILDE BEHREND
Social Sciences Research Centre, University of Edinburgh

SINCE the end of the War, British management has continuously been confronted with the question of finding effective incentives for labour. For some time advocates of payment by results thought they knew the answer. The shortage of labour and rising wages, however, seem to threaten the effectiveness of financial incentive schemes. Moreover, the belief that payment by results is the only effective mechanism of effort-control has been challenged by the actions of a few important undertakings. The first accomplishment to attract widespread attention was the speedy construction of the Esso Refinery, where workers were paid by time-rates and yet completed their task well before the planned date[1]. Another challenge was the decision in 1956 of the Vauxhall Company to change from a bonus system to time-rates. Ministry of Labour statistics[2] suggest that the period of the increasing adoption of payment by results in British industry may have come to a halt: the percentage of all workers in manufacturing industry who were paid by results rose from 33 in 1938 to 40 in 1951, but has remained constant between 1951 and 1955.

It is pertinent to ask what statistical facts are available on the question of the relative labour productivity of time-rates and payment by results. Unfortunately statistical data on this question which stand up to scientific scrutiny do not appear to exist, and it seems unreasonable to expect them to exist. For changes in industry scarcely ever take place in isolation; the introduction of payment by results is always part of wider changes and is normally accompanied by organizational and methods changes; any change in the intensity of labour effort cannot be isolated from the effect of other changes. The situations before and afterwards are rarely comparable, and there exist no standards for comparison. In the course of an inquiry, in which I communicated with two hundred firms by letter and visited fifty, I did not find a single case where the effectiveness of payment by results in raising labour productivity could be isolated and measured[3].

The only case, known to me, where the effect of payment by results has been demonstrated was in a controlled industrial experiment conducted by Wyatt[4]. In this experiment ten girl operators in a chocolate factory while working successively on five different processes were switched from a time-rate to a bonus and then to a piece-rate. On four out of the five jobs output increased when the bonus was introduced, and it rose further when the piece-rate was introduced. On the fifth job there was practically no change in the rate of output when the method of payment was changed. The experiment shows that there is no guarantee that the introduction of payment by results will increase output; the response depends, among other factors, on type of work.

In spite of this lack of guarantee and in spite of the absence of valid statistical proof of the effectiveness of payment by results, I found in my inquiry on financial incentives that nearly all the management representatives I interviewed believed that payment by results is effective in raising labour productivity and that there exist different standards of effort for time-rates and piece-rates. Twenty-two out of twenty-five people, who were prepared to commit themselves to estimates, considered that the productivity of piece-rates was at least 25 per cent greater than that of time-rates. They attributed the difference in all cases to the method of wage-payment and not to the level of earnings.

My evidence suggests that financial incentive schemes rest to a considerable extent on faith in their effectiveness rather than on proof of their effectiveness. Lack of scientific proof, however, does not mean that management's faith in payment by results is necessarily unfounded; lack of proof only means that the case is not established, not that it is disproved.

In order to gain more insight into the real issues involved it may be useful to approach them from a different angle.

The central problem which faces management in dealing with labour is that of securing a high and sustained level of effort. The problem arises because of the lack of precision of the employment contract. Nominally, the employment contract is an agreement which fixes the terms of exchange of work for money by defining the obligations of both parties; that is, the wage-payments to be made by the employer and the duties to be performed by the worker. In a dynamic situation, however, the duties to be performed by the employee cannot be clearly defined. They may differ from day to day, or over longer periods. Workers thus are taken on to perform varying work-assignments which means that what the employer purchases is not a given series of services but a supply of effort to perform particular types of services. The amount of effort involved in performing these duties is undefined.

This is so because effort is not a substance that can be measured; it is a subjective experience. Only the product of effort—output—can be measured. This presents a real dilemma—because of changing work-assignments a day's work cannot be defined in terms of output which is measurable; it can only be evaluated in terms of subjective standards of effort. An individual can say whether the effort he expends in performing a particular operation in a fixed time is equal to, greater or smaller than, the effort he expends on another operation in the same amount of time. He cannot quantitatively define the difference, but he can clearly distinguish different intensities of effort per unit of time. Evidence illustrating the distinction between different experiences of effort has been given by D. Roy[5]. Roy found that the workers distinguished three types of job: the 'gravy job', where high earnings could be achieved with little effort; the ordinary job, where reasonable earnings could be obtained with normal effort; and the 'stinker', where it was not possible to make reasonable earnings however high the effort.

The ability to distinguish different standards of effort makes it possible for management and workers to bargain about effort-intensity. In return for wage concessions, workers may agree to raise their stan-

dards of effort. This is essentially what a successful financial incentive scheme does: it represents an effort-bargain in which the worker agrees to raise his standard of effort in exchange for the guarantee of higher total earnings. All this involves the tacit assumption that more effort means more output.

The gap in the employment contract which arises from the impossibility of defining the intensity of effort is narrowed down by effort-bargaining. For although no absolute standard of effort can be established, agreements can be made about relative standards; that is, a worker can agree to raise his standards, and this increase would be visible (other factors remaining equal) in increased output. If one views financial incentive schemes as an effort-bargain one can argue that they will tend to be effective so long as both sides are aware of the bargain and keep their side of the agreement.

There is a danger that people concerned with the technical and human implications of the installation of financial incentive schemes lose sight of the fact that the aim of incentives is primarily a bargain between management and workers. The consultation of workers may thus become an issue of avoiding friction and of maintaining good industrial relations instead of one of agreeing on increased standards of effort. This will affect the effectiveness of the schemes.

If one concedes the possibility of effort-bargaining it becomes possible to visualize alternative types of effort-bargain. A wage-increase on time-rates, for example, could be made into an effort-bargain by linking it to an agreement on output targets.

The amount of effort-bargaining that takes place in a factory depends on the state of the labour and product market. Effort-bargaining is particularly important under conditions of full employment where the shortage of labour exercises constant pressures upon management. In such a labour market situation two types of bargaining, one initiated by management, the other by labour, go on side by side. Management will try to increase the level of effort which it obtains from its labour force without increasing costs per unit of output. Labour will try to increase the level of wages for a given level of effort. In trying to obtain a greater supply of effort out of its labour, management, if under pressure from the market for its products, will be in a weak bargaining position and may have to make wage-concessions. These may take the form of a deliberate toleration of loose rates—a disguised increase in wages to encourage an increase in the supply of effort. (A rate is loose if comparatively little effort is required to obtain normal earnings; it is tight if too much effort is required to obtain normal earnings.) Labour, being in a strong bargaining position, may be inclined to lower its standards of effort and this may necessitate the initiation of renewed effort and wage-bargaining. Labour may also show a tendency to attack all rates as tight and to press for rate-adjustments. Where there is unemployment or under-employment, attitudes will tend to be very different. For example, in a situation where work is frequently slack, management may tolerate low standards of effort, allied to low pay, and workers may be content with this because they like a leisurely pace of work. This would explain why some small firms who pay time rates amounting to low earnings are able to keep their labour-force and show a low rate of labour turnover.

Low standards of effort, necessitating effort-bargaining, may be the result of dissatisfaction. Changes in the worker's attitude to his job and rising discontent may give rise to restriction of effort. This fall in effort intensity may lead to the offer of increased wages for increased effort if management is under pressure to meet urgent orders. The result is an increased wage for the original standard of effort.

A constant process of effort-revision thus appears to take place: management considers whether it requires more effort; workers may relax their standards. Both revisions tend to lead to upward revision of wages.

The importance of effort-bargaining depends on type of work and organization of work; for type and organization of work determine the amount of choice an individual has in varying his supply of effort. In some industrial situations it is possible for management to control the speed of work by external controls of effort, such as the speed set by conveyor-belts or by machine-pacing. In such situations there is little opportunity for varying effort; the choice of the right speed is made by management (with or without consultation of the workers) and the effort-bargain consists in the worker's acceptance of management's choice of speed. In this type of situation effective control of effort on time-rates can be achieved. There appears to be a trend towards the increasing use of external controls of effort, not only for manual, but also for clerical and other types of work.

At the other extreme is the type of work where the individual worker sets his own pace and determines himself what speed of work he adopts. It is in this type of situation that financial incentives as a form of effort-bargaining and effort-control are important. In this case there are no direct external controls of effort. The controls which are brought into play are what the sociologist calls normative controls (moral codes which prescribe what is right, what ought to be done). The effort-bargain entered into in an incentive-scheme is an agreement on what standards of effort ought to prevail, and what difference there ought to be between output on time-rates and on piece-rates. It is an agreement to establish norms of output.

As effort cannot be measured, this raises some interesting issues. How is agreement on standards of effort arrived at when standards of effort can only be assessed by subjective value judgments? How is the rightness of a standard of effort established when it depends on the worker's experience of effort in doing the job as compared with his past experiences? What part does time-study play in all this?[6]. The subject is fraught with difficulties. Yet, in practice, agreement is usually reached, and the system seems to work although it is based on no objective criteria. What seems to matter in making it work is the establishment of an acceptable and effective effort-bargain based on normative or external control of effort. Time-study may play an important part in striking such a bargain.

[1] See Gray, A. P., and Abram, Mark, "Construction of Esso Refinery, Fawley" (Brit. Inst. Management, 1954).

[2] *Min. Lab. Gazette* (April 1956).

[3] For more details of this inquiry, see Behrend, H., "The Effort Bargain", *Indust. and Lab. Relations Rev.* (to be published).

[4] Wyatt, S., assisted by Frost, L., and Stock, F. G. L., "Incentives in Repetitive Work", I.H.R.B. Rep. No. 69 (1934).

[5] Roy, D., "Goldbricking and Quota Restriction", *Amer. J. Sociol.*, 57 (1951–52).

[6] Few people nowadays deny that there is a residue of subjective judgments involved in time-study. For a discussion of some of the difficulties mentioned here compare: Ryan, T. A., "Fatigue and Effort in Relation to Standards of Performance and Systems of Payment", *Internat. Lab. Rev.*, 65 (1952). Whyte, W. Foote, "Money and Motivation" (Harper Bros., 1955). Foote Whyte describes time-study as a "guessing game". Behrend, H., *op. cit.*

OBITUARIES

Dr. Bashir Ahmad

Dr. Bashir Ahmad, who died suddenly in the home of his friend and colleague, Colonel M. K. Afridi, at the University of Peshawar on March 14, was an unassuming man who had won the position he held in the scientific life of Pakistan by his ability in many fields. A devout Moslem, he received his early scientific training at the non-denominational Forman Christian College in Lahore, afterwards gravitating towards biochemistry and nutrition, and working for three years from 1928 with Prof. J. C. Drummond at University College, London.

This was an experience he never forgot, and which not only shaped his future career in chemistry but also gave him a sympathy for and understanding of Britain which was never shaken. On returning to India he became a lecturer in chemistry, and eventually professor of organic chemistry in the University of the Punjab. There he continued his work on carotenoids. Later he joined Sir Shanti Bhatnagar in the Indian Department of Scientific and Industrial Research, and transferred to Calcutta, where he became interested in the B group of vitamins.

On partition of India, he opted for Pakistan and returned to Lahore as head of the Institute of Chemistry, and became eventually vice-chancellor of the University of the Punjab. It was during his tenure of this office that he came to Cambridge for the Congress of the Commonwealth Vice-Chancellors, and received the honorary degree of LL.D., a tribute of which he was very proud, as he was of his more recent election as a Fellow of University College, London. In 1953 he was asked by the Pakistan Council for Scientific and Industrial Research to be director of the West Regional Laboratory at Lahore, one of the three regional laboratories established by the Council.

The progress of this Laboratory is characteristic of his skill and energy as an organizer. The preliminary plan of work, and the outlines of the main divisions, came from the committee of which he was chairman in that same year. Work began in a limited way in the Institute of Chemistry, and in 1955 a magnificent site on the Ferozepur Road, adjoining the new buildings of his old College, the Forman Christian College, had been acquired. 1956 saw the completion of one building, and this summer will see two more splendid new institutes finished, with spacious workshops, and houses for the staff.

In a country which is short of well-trained men, more and more burdens are placed on the shoulders of those willing to accept them. Dr. Bashir Ahmad organized and ran the Pakistan Association for the Advancement of Science, edited its publications, examined at the Universities of Dacca and Karachi, organized local meetings of World Brotherhood, was in process of organizing an Urdu Academy, led scientific missions to China, and ultimately had so little leisure that he could not take the rest which his medical adviser ordered.

Dr. Ahmad's scientific researches are known to workers in nutrition, and will not be forgotten, but it is not for this that he will mainly be missed. He will be missed by his country as a scientist (and above all because he was the only well-trained nutrition worker in Pakistan), by those who knew him and had had the rare privilege of working with him in building up his new organization and visiting his home and family, and most of all by the young graduates who, feeling rather lost in the underdeveloped country into which graduation thrust them, found in him a man who never failed them with sympathy, help and advice. To half Lahore and countless students in both West and East Pakistan he was 'Doctor Bashir' or 'Doctor Sahib'. Men were willing, once they knew him, to work at Lahore for less than they could get in industry. "No man is an island" is a truth which Pakistan will come more and more to realize in years to come, and one who knew his plans for Lahore and what they meant to him and would have meant to Pakistan can only hope that his labours will not have been in vain.

J. C. Fidler

Mr. K. W. Tremellen

Kenneth William Tremellen, who died on April 3, was one of the pioneers in radio research. He gained his experience in handling radio receivers when he was an assistant to Captain H. J. Round in the Marconi Company in the years before the First World War, and he did outstanding work in Flanders, using some of the early valve sets in the interception of radio signals and in locating enemy transmitters by a network of direction-finding stations. In particular, he plotted the Zeppelin raids and the movements of the German Fleet.

It was natural that he should be chosen later by the Marconi Company to undertake a journey around the world making field-strength and direction-finding measurements of the long-wave stations and of atmospherics. The mass of information thus obtained formed the material for a classical paper jointly with Eckersley, Round and Lunnon. With the advent of short-wave communications he began a long series of observations which supplied most of the data around which T. L. Eckersley wrote his remarkable papers published by the Institution of Electrical Engineers. This work included some of the earliest records of scattered signals and around-the-world echoes.

The present system of charts of world-wide ionospheric conditions published each month by various organizations had their origin in the 'shadow charts' which he devised thirty years ago. At the beginning of the Second World War he was already constructing quite detailed charts based largely on his personal knowledge of high-frequency propagation conditions, and he played a leading part as the scientific officer-in-charge of the Inter-Services Ionosphere Bureau established at Great Baddow, for which he was awarded the American Medal of Freedom.

'Trem', as he was affectionately known to all his friends, was an experimenter with a genius for careful and patient observation and for distinguishing between reliable and spurious results. He made no claim to be an expert in mathematics or physics, but he had a healthy scepticism towards erudite theoretical papers reared on highly conjectural hypotheses or doubtful experiments. It was not unusual when reading a journal that had already passed through his hands to come across such marginal comments as "so what ?" or "very fluffy".

He was a modest man of great courtesy and as a bachelor he led a quiet and simple life. On his retirement in 1952, he went to live with friends in south-east London, where he found great pleasure in gardening and some of the domestic arts. He retained one link with radio, for he continued to serve in a personal capacity on the Ionospheric Communications Committee of the Department of Scientific and Industrial Research, where his knowledge of short-wave circuits was invaluable. When he attended the meeting on March 29 he was obviously failing in health, but it came as a shock to hear a week later that he had died within a few hours of being taken suddenly ill.

His unique knowledge of propagation conditions was of a kind that was difficult to commit to paper. He wrote comparatively little, and with his passing the world of radio has suffered a great loss.

G. MILLINGTON

Dr. G. E. Foxwell, C.B.E.

GEOFFREY EDWIN FOXWELL, who died on April 26 after a short illness, was born in 1892. He obtained his early education at the Hinckley Grammar School and at All Saints' School, Bloxam. His first appointment in science and fuel technology was as a junior chemist with the Koppers Coke Oven and Bye-Product Co. of Sheffield, where he soon showed ability well above the average. In 1916, at the early age of twenty-four, he became coke oven manager to the Alloa Coal Co., but later returned to the Koppers Company as chief chemist. During this period his energy and drive were such that he took the B.Sc. degree of London and later gained the D.Sc. degree for outstanding work on the plastic state of coal.

In 1924 Foxwell was appointed senior research chemist to the Gas Light and Coke Company in London, but remained only a short time before again returning to the Koppers Company as chief technical officer. He finally left full-time service with that Company in 1932, though retained for a time as consultant, to move to London to take up various professional activities. These activities included a close association with Clayton, Son and Co., of Leeds, gas and constructional engineers, and considerable work in technical journalism. His articles were always clear, interesting and informative, and it was in this field that he excelled.

Foxwell's interests were by no means narrow. During the Second World War he was successively vice-chairman and chairman of the British Chemical Plant Manufacturers' Association, and a member of the Fuel Efficiency Committee of the Ministry of Fuel and Power. He was also editor, and author of several chapters, of the book, "The Efficient Use of Fuel", first published in 1944 by H.M. Stationery Office. A founder member of the Institute of Fuel, he served on the Council of the Institute continuously from 1942 and was president during 1951–53. He was a prominent member of the Committee on Air Pollution under the chairmanship of Sir Hugh Beaver. He was made C.B.E. in the Birthday Honours List of 1955. His outside interests included the chairmanship of the Epsom Sports Club and he was an active player of cricket to the end.

Foxwell never spared himself. He was thorough and painstaking in whatever task he undertook, and always friendly, helpful and considerate.

A. PARKER

NEWS and VIEWS

Civil Aircraft Research and Development, Ministry of Supply: Mr. J. M. Gray

MR. J. M. GRAY retired from the post of director of Civil Aircraft Research and Development with the Ministry of Supply in April 1957, after thirty-five years in the Government Service. He was born in Lairg, Sutherland, in 1896, and after serving in the R.N.A.S. and R.A.F. for three and a half years in the First World War he entered the University of Glasgow, where he graduated in engineering, including aeronautics as a special subject. In 1923 he joined the Airworthiness Department of the Royal Aircraft Establishment and was engaged in assessing the structural and aerodynamic qualities of aircraft designs, both military and civil. He assisted in preparing and compiling the first editions of the well-known aircraft handbooks *A.P.*970 and *A.P.*1208. The latter was eventually absorbed in "British Civil Airworthiness Requirements", now issued by the Air Registration Board. Mr. Gray also assisted in instituting the Approved Firms Scheme in conjunction with the Resident Technical Officer Organization, which he supervised until 1931. During that period he produced a "Handbook of Aerodynamic Calculations" for the use of the Department and resident technical officers.

In 1931 he was transferred to the Air Ministry. During his first year there he initiated and developed new methods for the more rapid checking of performance estimates for tender designs. These methods were afterwards published in the "Handbook of Aeronautics". After a further brief posting to the Royal Aircraft Establishment, Mr. Gray was recalled in 1937 to the Air Ministry to assist the newly appointed director of Civil Aircraft Research and Production. During the War he was, until 1944, concerned mainly with the development of equipment and installations for military aircraft and he headed a mission to the United States to investigate progress of these items in that country. In 1944 he headed a small section in the Ministry of Aircraft Production, set up to co-ordinate the development of post-war civil aircraft and associated equipment. During this period he acted as technical adviser to the Brabazon Committee. He accompanied Lord Winster's delegation in 1946 as technical adviser, to take part in the South Pacific Air Transport Council in New Zealand, which was in the process of setting up the British Commonwealth Pacific Airlines. During the latter part of his career he was closely associated with the development of civil transport aircraft for the Airline Corporations, such as Britannia, Comet and Viscount.

Mr. H. Templeton

MR. H. TEMPLETON has been appointed to succeed Mr. Gray. He was born in 1914. After taking a

first-class honours degree in civil engineering at the University of Manchester in 1935, he joined the design department of Armstrong Whitworth the same year. He was initially engaged on the development of stress analysis methods for monocoque fuselages and box spar wings in connexion with the design of the Ensing. Later, as head of a special research and development section, he was concerned, among other things, with boundary layer suction, the aero-elastic characteristics of tailless aircraft, gust alleviating devices, and the economics of turbo-jet aircraft.

In 1947 he joined the Flutter and Vibration Division of the Royal Aircraft Establishment as a principal scientific officer in charge of the theoretical section. In this capacity he took active measures to encourage the aircraft industry to undertake its own flutter investigations, and eventually to increase the scope of flutter work generally. In 1950 he was appointed head of the Division, and continued to lead activities in the aircraft flutter field, notably in the direction of model testing and full-scale flight flutter testing, and in the application of high-speed computors to theoretical flutter investigations. Mr. Templeton is the author of a Royal Aeronautical Society monograph on "Mass Balancing of Aircraft Control Surfaces" and he is a fellow of that Society. In July 1956 he was appointed assistant director of Civil Aircraft Research and Development at the Ministry of Supply.

Royal Aeronautical Society

Honorary fellowship of the Royal Aeronautical Society has been accepted by H.R.H. Prince Bernhard of the Netherlands. Miss B. Voyce, an ex-member of the staff, has been appointed an honorary companion of the Society. The following awards have been made by the Society: *The Society's Gold Medal* to Prof. J. C. Hunsaker, for his contributions to aeronautical research and education, including his inspired chairmanship of the National Advisory Committee for Aeronautics, whose work has so greatly benefited aeronautical activities everywhere (this is the highest honour which the Society can confer for work of an outstanding nature in aeronautics); *The Society's Silver Medal* to Mr. M. B. Morgan, for his contributions in the execution and direction of aeronautical research and development; *The Society's Bronze Medal* to Mr. F. B. Greatrex, for his work on the reduction of noise from aero-engines; *The British Gold Medal for Aeronautics* to Mr. R. L. Lickley, for his outstanding practical contributions to aircraft design and development; *The British Silver Medal for Aeronautics* to Mr. Charles Abell, for his engineering achievements contributing to efficiency in airline operations; *Wakefield Gold Medal* to Mr. Caradoc Williams, for his contributions to the development and use of radio aids to navigation; *R. P. Alston Memorial Medal* to Mr. Bernard Lynch, for his practical achievement in the flight testing of ejector seats; *George Taylor (Australia) Gold Medal* to Mr. G. Forrest and Mr. K. Gunn, for their paper on problems associated with the production and use of wrought aluminium alloys; *The Simms Medal* to Mr. E. G. Broadbent, for his paper on aeroelastic problems in connexion with high-speed flight; *The Edward Busk Memorial Prize* to Mr. I. M. Davidson, for his paper on the jet flap; *The Orville Wright Prize* to Dr. B. S. Stratford, for his papers on the jet flap published in the *Aeronautical Quarterly*; *The Herbert Akroyd Stuart Memorial Prize* to Dr. J. S. Clarke, for his review of some combustion problems associated with the aero gas turbine; *The Branch Prize* to Mr. E. R. Major, for his paper on some maintenance aspects of Viscount operation; *The Navigation Prize* to Mr. R. A. Burberry, for his paper on aerial systems for aircraft; and *The Usborne Memorial Prize* to Mr. T. M. Corson, for his paper on the propeller-turbine in airline service.

U.K. Atomic Energy Authority: Safety Executive Committee

The Atomic Energy Authority Act, 1954, places on the Atomic Energy Authority the duty of securing that no ionizing radiation from any of its premises or from any waste discharged from its premises shall cause any hurt to any person or damage to any property. The Authority has carried out these responsibilities through a number of committees dealing with the various aspects of safety policy. These bodies have now been re-organized into two main committees which will be served by a newly formed Safety Branch. The functions of the Safety Executive Committee are to consider the safety policy of the Authority in the design, siting and operation of reactors, process plants and laboratory installations, using the standards recommended by the Health Advisory Committee (see below); to approve, for issue by the Authority, general codes of practice in such matters; and to refer to the Reactor Safety Research Committee such items as they consider should be the subject of basic research.

This Committee is served by two sub-committees, namely, the Reactor Safety Committee, which has absorbed the Reactor Location and Reactor Operation Panels of the old Project Health Committee; and the Ancillary Establishments Safety Committee, which covers all plants and experimental facilities other than reactors. There is also an independent Reactor Research Committee, one of the functions of which is to advise on the technical suitability of sites proposed for nuclear facilities of all sorts, including nuclear power stations.

Health Advisory Committee

The Health Advisory Committee is composed of the chief medical officers and the chief health physicists of the Authority and the Authority's consultants. The functions of this Committee are to consider, and advise the Authority on, the effects on public and occupational health and safety of the atomic energy programme; and to identify research problems on which work is required in relation to the control of health hazards in the development of atomic energy. This Committee also defines standards of occupational and non-occupational exposure to radiation and radioactive substances and passes these standards to the Safety Executive Committee for application.

The newly formed Safety Branch will meet the Authority's need for a permanent staff to serve this Committee structure and will operate from the headquarters of the Industrial Group at Risley. It will provide the focus for consideration not only of the Authority's own proposals but also of industrial proposals put to it either directly or through Government departments. It will service the main committees and sub-committees and will furnish the

inspection service which will be needed to ensure the maintenance of safe working within the Authority. It will provide technical advice in the legislative field and draft, with the committees, codes of practice in design and operation. The Authority has appointed Mr. F. R. Farmer to the post of chief safety officer in charge of the Safety Branch.

Migration from the United Kingdom

MUCH has recently been written about the loss to Britain of skilled workers and technicians who migrate overseas. In a recent broadsheet ("Britain and Commonwealth Migration", *Planning*, No. 409), Political and Economic Planning sets out the basic data relating to migration. In the years 1953–55, the United Kingdom lost some 57,000 people on balance by migration over the long sea routes: the movement was made up of 132,000 emigrants and 75,000 immigrants. Most emigrants go to Canada, Australia, the United States and New Zealand; the four countries providing the bulk of immigrants are Australia, India and Pakistan, Canada and the British West Indies, respectively. It is clear that quantitatively the net loss to Britain of 57,000 persons in two years is not a serious matter in a population of 50,000,000, but emigration is selective, and among the emigrants, people in productive age groups and with high skills are represented out of proportion to their numbers in the population. Thus, of the women emigrants to Canada 66·3 per thousand were nurses, as against 7·2 per thousand in the general population. Among men, 22·2 per thousand were mechanical engineers as against 1·2 per thousand in the population.

The broadsheet poses a number of questions which need consideration. Do the benefits to the Commonwealth as a whole which result from a redistribution of labour offset the disadvantages which a loss of skilled men inevitably entails for Great Britain? Will migration result in long-term intangible benefits for the home country? To what extent will immigrants be capable of replacing emigrants to the Commonwealth? What are the social and economic problems raised by emigration? In the present state of knowledge no definite answers can be given to any of these problems. The broadsheet shows the need for a good deal more empirical research on this hitherto comparatively neglected problem.

Trinidad Field Naturalists' Club

THE Trinidad Field Naturalists' Club was founded in July 1891. Soon afterwards the decision was taken to publish a journal, the first number appearing in April 1892. Thereafter, the journal appeared every two months for four years, running to two volumes of just over three hundred pages each. Publication ceased in February 1896; but the Club continued to flourish until 1907, when it lay dormant until July 1924; it was then revived and entered upon its second phase. Attempts were made to re-issue the journal, but these were not successful. The Club has now entered upon its third phase and plans have been made for the publication of an annual journal. The first issue contains a number of interesting articles. Among them is one describing a celebrated occasion in 1938 when a boa constrictor laid eighteen eggs, five of which developed; in a normally viviparous reptile this abnormal birth of young macajuels was almost certainly due to adverse physiological conditions. The journal may be obtained from Dr. V. C. Quesnel, c/o Colonial Microbiological Research Institute, Port-of-Spain, Trinidad, at a cost of 0.55 dollar, B.W.I.

Design of Equipment for Human Use

A MEETING on "The Design of Equipment for Human Use" was held at Cambridge in the Applied Psychology Research Unit of the Medical Research Council during March 26–28. There were sessions on the military and industrial aspects of work design, on the use and abuse of simulators, on equipment design for training and maintenance, and on automatic data analysis in human research. There were also twenty practical demonstrations of various aspects of this work, by members of the Applied Psychology Research Unit and also by visiting speakers. The meeting was attended by eighty representatives, who came from the three Services and the Ministry of Supply, as well as from industrial firms, university departments, and various nationalized industries and government organizations in Britain. A summary will be sent on request to the Medical Research Council, Applied Psychology Research Unit, 15 Chaucer Road, Cambridge.

Conference on Extra-atmospheric Cosmic Radiation Research

A CONFERENCE of cosmic-ray physicists interested in the application of emulsion techniques and a number of engineers and government scientists interested in the scientific application of rockets was held in Baltimore on March 29 under the sponsorship of RIAS (2120 North Charles Street, Baltimore 18, Maryland). The main business of the conference was the consideration of the possibility of studying by the use of nuclear emulsions cosmic-ray primaries outside the atmosphere, and in particular, of detecting the presence of any hitherto unobserved component of a low penetrating power. Mr. R. Patterson and Mr. W. J. Benckert, engineers of the Advanced Design Department of the Martin Company of Baltimore, presented a preliminary design of a vehicle which would allow an oriented stack of 50 lb. of emulsions to be exposed for 40 min. with a total shielding of less than 0·1 gm./cm.^{2} while outside the atmosphere. This vehicle, which is to be launched in a vertical shot, would be capable of preserving the emulsion during re-entry into the Earth's atmosphere and the eventual fall to Earth. During the discussion afterwards it became evident that such a vehicle could also be used to great advantage for a number of other experiments without interfering with the emulsion studies.

In view of the great scientific potentialities of such a cosmic-ray experiment, the physicists formed a committee to consider it in more detail and to arrange a programme of co-operative research by all interested scientists at such time as the vehicle is launched. The membership of the committee is: G. Groetzinger (chairman), M. F. Kaplon, S. A. Korff, E. P. Ney, W. J. Otting, A. Pevsner, M. Pomerantz, B. Rossi, M. Schein, M. M. Shapiro, S. Silverman and H. Yagoda. In a later meeting the committee adopted the title "The National Committee for Extra-Atmospheric Cosmic Ray Research" and decided to consider also the possibility of other new extra-atmospheric cosmic-ray experiments. At this meeting, J. A. Simpson joined the committee and W. A. Benckert was made a consultant.

Dust Content and Visibility in Dust Storms

An article by W. S. Chepil and N. P. Woodruff on sedimentary characteristics of dust storms and dust concentration, published in the *American Journal of Science* (**255**, February 1957), gives numerical data for a subject on which little similar information is available, but which is of considerable importance to the design of machinery for operation in arid regions. The authors caught dust at heights of from 4 to 20 ft. in lorry-borne apparatus in dust storms in Kansas and Colorado, in the United States. At the same time and on clear sunny days only, they made visibility observations, using dark visibility objects, and also measured the wind speed. From their work they are able to give numerical rules for the variation of dust density with height, and extrapolating upwards with an exponential relation, total atmospheric dust content, visibility and dust content, and the amount of dust transported through a vertical square mile. The extrapolation to a height of one mile from observations to only 20 ft. may be subject to considerable error. The authors give some justification for it from the work of Wilhelm Schmidt ("Massenaustausch in freier Luft", 1925). Their figures give a vivid impression of the meaning of the term 'dust bowl'. The relation found between visibility V (in miles) and dust concentration is $V = 0{\cdot}9\ C_a^{-0{\cdot}8}$, where C_a is the concentration of dust at a height of 6 ft. in mgm./ft.^{3}. Details are given of some dust storms ranging from one with a dust concentration at 6 ft. of 0·09 mgm./ft.^{3}, visibility 4·8 miles, and an average rate of soil removal 53 tons/hr./vertical sq. mile, to one with corresponding values of 37·6 mgm./ft.^{3}, 0·05 miles and 47,951 tons/hr./vertical sq. mile. The values for an average storm are concentration 6·54 mgm./ft.^{3}, visibility 0·93 miles and rate of soil removal 9,945 tons/hr./vertical sq. mile.

Level of the Caspian Sea

During the past twenty-five years the level of the Caspian Sea has fallen by 2½ metres, and this is affecting shipping, fisheries, petroleum winning and salt deposition in Kara-Boghaz-Gol. Recently, a conference on this subject, organized by the Academy of Sciences of the U.S.S.R., took place in Astrakhan. Prof. B. A. Apolov gave a summary report in which he said that the lowering of the level of the Caspian Sea is due to the warming up of the climate of the northern hemisphere and to the increased utilization of the rivers of the region for irrigation and water supplies. He estimates that by 1970 the level may have fallen another metre. To remedy this, he proposed the construction of a dam in the northern part of the Caspian Sea. Other proposals (Dvorov, I. M., *Priroda*, No. 1, 111 ; 1957) included the diversion of the upper courses of Onega, Northern Dvina and Pechora Rivers into the Volga, or the diversion of the Siberian rivers into the Caspian Sea.

Royal Military College of Science, Shrivenham: Studentships

The War Office and Ministry of Supply announce that the following have been awarded civilian studentships, tenable for three years, at the Royal Military College of Science, Shrivenham: J. H. Garvie (Glasgow Academy), G. H. Gregg (Cockburn High School, Leeds), D. A. G. Pedder (Admiralty) and K. R. Thomas (Redruth County Grammar School). These studentships are sponsored by the Ministry of Supply on behalf of all the Government departments employing scientists. Their object is to give to young men who intend to enter the Scientific Civil Service a university education in science or engineering. To this end, the War Office makes available some places on the Young Officers' Degree Course at the Royal Military College of Science, Shrivenham. On these courses students are prepared for the University of London degree of B.Sc. (Special) in chemistry, physics or mathematics or B.Sc. (Engineering). In addition to a first-class education in science or engineering, the Royal Military College of Science provides a useful background education for the study of defence research problems so that the courses at the College are particularly suitable for training young scientific officers for work in Government defence research establishments.

Supply of Scientists and Technologists for Industry

A conference on "The Supply of Scientists and Technologists for Industry", under the auspices of the British Association, will be held in the University of Leeds on July 5. The conference has been arranged in connexion with the Report of the Science and Industry Committee, published by the Oxford University Press on May 31, under the title of "Industry and Technical Progress", by Prof. C. F. Carter and Prof. B. R. Williams, the directors of the two research units appointed by the Committee. The conference will discuss Chapter 9 of this report, which is devoted to a consideration of some of the problems connected with increasing the supply of trained men and women for industry. These include certain problems confronting the schools, colleges and universities, such as early leaving, early specialization, university entrance requirements, the type of university degrees, and the recruiting of science teachers for schools and staff for the technical colleges. Some of the problems confronting industry are also to be discussed, including the qualities industry looks for in a scientist or technician, the shortage of scientific staff, salaries, chances of promotion, training schemes in firms, recruitment by large and small firms, efficiency in the use of scientists and technologists by industry, and the shortage of draughtsmen. The conference is open to all who are interested in this subject, without fee. Applications for tickets should be addressed to the Secretary, British Association, Burlington House, Piccadilly, London, W.1.

Electronics Course at Harwell

The twelfth specialized course on the design, use and maintenance of electronic instruments used in nuclear physics, radiochemistry and in work with radioactive isotopes will be held in the Reactor School, Atomic Energy Research Establishment, Harwell, during July 15–19. The course will include lectures, demonstrations and practical work on many types of electronic instruments, including counters, d.c. and pulse amplifiers, scalers and rate meters. The course is intended primarily for physicists and electronic engineers: the fee for the course is 25 guineas, which does not include the cost of accommodation in the district, but local accommodation can be arranged on request. Since the number of places on the course are limited, application forms should be returned as soon as possible, and in any case before June 21. Application forms and further information can be obtained from the Divisional Administration Officer, Electronics Division, Atomic Energy Research Establishment, Harwell, Nr. Didcot, Berkshire.

University of Leeds: Appointments

THE following appointments in the University of Leeds are announced: Dr. G. R. Tristram, as professor of leather industries from October 1; Dr. M. Atkinson, as lecturer in the Department of Medicine; Mr. W. C. Gregory, as lecturer in geology from September 1; Mr. I. R. McDougall, as lecturer in chemical engineering from September 1; Mr. F. O'M. Shiel, as lecturer in pathology; Mr. R. W. Spencer, as lecturer in chemical pathology from August 1; Dr. R. J. Williams (at present Turner and Newall research fellow in the Department of Physical Chemistry) as Brotherton research lecturer in physical chemistry for one year from October 1.

Donations to the University building fund have now brought the total amount in the fund to £497,828.

University of London: Appointments

THE following appointments in the University of London are announced: Dr. John Brown, lecturer in University College, to the University readership in electrical engineering tenable at that College; Dr. J. A. Clegg, senior lecturer in physics at the Imperial College of Science and Technology, to the University readership in physics; Dr. Henry Elliot, senior lecturer in physics at the Imperial College of Science and Technology, to the University readership in physics; and Dr. Robert Latham, senior lecturer in physics at the Imperial College of Science and Technology, to the University readership in high temperature physics, all tenable at that College.

The Night Sky in June

FULL moon occurs on June 12d. 10h. 02m. U.T., and new moon on June 27d. 20h. 53m. The following conjunctions with the Moon take place: June 1d. 09h., Mars 6° N.; June 6d. 01h., Jupiter 6° N.; June 11d. 14h., Saturn 0·0° S.; June 30d. 00h., Mars 6° N. In addition to these conjunctions with the Moon, Mars is in conjunction with Pollux on June 11d. 06h., Mars being 5·5° S., Mercury with Aldebaran on June 18d. 13h., Mercury being 4·2° N., and Venus with Pollux on June 26d. 04h., Venus being 5·4° S. Mercury rises a short time before the Sun, but observation will be difficult. Venus sets rather more than an hour after the Sun, and is visible as a bright object low in the west just after sunset. Mars is visible in the west for a short time after sunset, its stellar magnitude being + 2·0. Jupiter sets at 1h. 15m., 0h. 20m. and 23h. 25m. at the beginning, middle and end of the month, respectively; it passes from Leo into Virgo on June 11. Its stellar magnitude is − 1·6, and its distance from the Earth in the middle of the month is 500 million miles. Saturn sets at 4h. 10m., 3h. 10m. and 2h. 05m. on June 1, 15 and 30, respectively; it is retrograding in Ophiuchus, and is north of Antares. The stellar magnitude of Saturn is + 0·2 and its distance from the Earth on June 15 is 840 million miles. There is one occultation of a star brighter than magnitude 6, observation being made at Greenwich: June 11d. 0h. 25·7m., ω^1 Sco. (*D*); *D* refers to disappearance. The summer solstice occurs on June 21d. 16h.

Announcements

MR. J. R. V. DOLPHIN, who has been chief engineer to the Weapons Group of the United Kingdom Atomic Energy Authority since 1951, has been appointed chief engineer to the Authority's Research Group. He will take up his new duties at Harwell on August 1.

DR. I. BERNARD COHEN, associate professor of the history of science and of general education at Harvard University, will deliver a lecture on June 13 at 4.15 p.m. in the Clarendon Laboratory, Oxford, on "Wave and Corpuscular Theories of Light from Newton to Maxwell".

AT a recent meeting of the Nutrition Society the following officers were elected: *President*, Dame Harriette Chick; *Hon. Secretary*, Dr. R. J. L. Allen (Beecham Foods, Ltd., Brentford, Middlesex); *Hon. Treasurer*, Dr. W. F. J. Cuthbertson; *Hon. Editor*, Dr. S. K. Kon; *Hon. Programmes Secretary*, Miss D. F. Hollingsworth. Dr. G. H. Bourne and Dr. A. J. Amos retired after five years service as hon. secretary and hon. treasurer, respectively.

THE award of the Corday-Morgan Medal and Prize, consisting of a silver medal and a prize of 200 guineas, is made annually to the chemist of either sex and of British nationality who, in the judgment of the Council of the Chemical Society, has published during the year in question the most meritorious contribution to experimental chemistry, and who has not, at the date of publication, attained the age of thirty-six years. Copies of the rules governing the award can be obtained from the General Secretary of the Chemical Society, Burlington House, London, W.1. Applications or recommendations in respect of the award for 1956 must be received not later than December 31, 1957, and applications for the award for 1957 are due before the end of 1958.

THE 363rd meeting of the Biochemical Society will be held in the Department of Chemistry of King's College, Newcastle upon Tyne, on June 28, starting at 11.15 a.m.

A JOINT meeting on "The Control of Chemical Additives in Food" of the Food Law Institute of the United States, the Food Group of the Society of Chemical Industry, the Society for Analytical Chemistry and the Association of Public Analysts, of Great Britain, is to be held at the Royal Institution, London, on July 26. Further details can be obtained from the Society for Analytical Chemistry, 14 Belgrave Square, London, S.W.1.

THE Nutrition Society is to hold a symposium on "Flour and Bread" in the Anatomy School at Cambridge on July 5 and 6. The chairman will be Sir Rudolph Peters (Biochemistry Department, Institute of Animal Physiology, Babraham, Cambridge) and the following contributions have been arranged: Dame Harriette Chick (Cambridge): "Wheaten Bread: a Historical Sketch"; Dr. C. R. Jones (St. Albans): "Essentials of the Flour Milling Process"; Dr. E. M. Widdowson (Cambridge): "Problems and Pleasures of Human Experiments"; Prof. R. A. Morton (Liverpool): "The Report of the Panel on Flour"; Dr. H. M. Sinclair (Oxford): "Nutritional Aspects of High-extraction Flour"; Dr. D. W. Kent-Jones (London): "The Case for Fortified White Flour"; Dr. J. R. Nicholls and Mr. J. R. Fraser (London): "Analytical Problems in the Determination and Control of Extraction Rates". Further particulars can be obtained from the Hon. Programmes Secretary of the Nutrition Society, Miss D. F. Hollingsworth, c/o Ministry of Agriculture, Fisheries and Food, Great Westminster House, Horseferry Road, London, S.W.1.

ECONOMIC AND EDUCATIONAL DEVELOPMENTS IN MALTA

SUBJECT to the approval of Parliament, the British Government agreed with the Government of Malta on February 27 to contribute a total of £6,077,000 to the Maltese budget for 1957–58, of which £899,000 is towards the ordinary budget deficit, £540,000 for war damage compensation and £4,638,000 to the capital budget, including war damage grants and Colonial Development and Welfare grants. This total compares with £2,705,318 for 1954–55, £4,382,392 for 1955–56 and £5,433,778 for 1956–57, and the financial statement for 1957–58 issued to the Legislative Assembly on March 8, 1957, pays tribute to Britain's growing help to the people of Malta in their economic difficulties.

Referring to the increasing tempo with which the basic facilities for economic development are being strengthened, the Statement points out that the cost of extracting and storing additional water supplies is not greatly different from that in the United Kingdom, but there is much leeway to be made up for years of under-investment. For 1957–58, estimated expenditure on water development is £1,020,630, compared with £493,038 in 1956–57, £239,603 in 1955–56 and £150,466 in 1954–55, and schemes are in hand which could give an increase of just over 50 per cent on the present daily production of nearly 7 million gallons.

The harbour development project is estimated to cost about £2 million, of which £295,000 is expected to be spent in 1957–58, but it will be two years before the first deep-water berths come into operation, and in the meantime the Malta Tug and Lighter Co. is to purchase, under a Government guarantee, nine to twelve steel lighters, designed to Government specification, to relieve congestion. Good progress is being made with the change-over in the electricity distribution system, which is now scheduled for completion by December 1958 instead of April 1960. The old coal-gas plant is being replaced by a modern catalytic oil-gas plant, and up to 5,000 consumers will be supplied from a liquid petroleum bottling plant at a capital cost for both projects estimated at £231,000.

In technical education 200 boys will be admitted to the new Boys' Technical School at Kordin in September 1957 and 200 annually thereafter until the complement of 1,000 is reached, while work will commence on two new technical schools in 1957–58, one for boys and one for girls, and the new Technical School and Lyceum should be completed in 1957–58. It is hoped shortly to introduce a two-year course for emigrants at the Marsa Industrial Training Centre and to arrange with the United Kingdom Ministry of Labour to place the trainees in factories where they will get practical experience of operating modern machinery and using modern techniques.

Industrial development was seriously set back by the Suez crisis; but the Maltese Government hopes to overcome some of the credit difficulties with its proposed 'Aids to Industry' Bill, and in the 1957–58 estimates £30,000 is earmarked for an industrial estate and £45,000 for loans and grants to new industries. The considerable assistance now being given to farmers and fishermen is stemming the exodus from these industries: provision for fisheries has been increased to £163,520 and for agriculture to £421,466. Great emphasis is being placed on agricultural education and training, and next year trainees will be sent to agricultural colleges in the United Kingdom with a view of eventually replacing the overseas experts at present helping Malta. The road programme for 1957–58 concentrates on roads which can be justified on economic grounds, besides giving employment to unskilled labourers, and the estimate is for £382,100 compared with £442,887 in 1956–57.

In reviewing the revised estimates for 1956–57, which show an estimated deficit of £692,983 in the Ordinary Budget and a deficit of £2,498,190 in capital expenditure, the Statement notes that the contribution from the United Kingdom includes £1,674,392 for war damage and reconstruction, £347,049 from Colonial Development and Welfare grants, and £156,000 towards emigration. Tribute is paid to the work of sixty-seven overseas experts in implementing new development schemes, but the Maltese Government is determined to improve the opportunities available for capable Maltese, and since March 1955 sixty-five Government employees have been seconded for training abroad. During 1957–58 a further eighty-eight will attend courses in English universities and other seats of learning, of whom thirty will be from the Ministry of Education, seventeen from the Ministry of Agriculture, sixteen from the Ministry of Health and eight from the Ministry of Works.

Finally, the Statement concludes that the flow of new capital should shortly make it possible for every citizen to contribute much more towards the welfare of the State than was possible in the past, and the Maltese people should no longer continue to invest their entire savings abroad. It should become feasible to launch local Government-backed bonds which could be utilized to set up local industries in Malta.

THE CRICHTON-MILLER REPORT

AT the end of 1956, Mr. D. Crichton-Miller, headmaster of Fettes College, Edinburgh, visited Malta on the invitation of the Prime Minister, the Hon. Dom Mintoff, "to review the progress made in the last 21 months in the provision of education; to consider future developments, particularly in higher and technical education; and to suggest ways in which these developments can be effectively related to the economy of Malta". Mr. Crichton-Miller has since submitted his report (Office of the Minister of Education, Valetta, Malta).

Malta is facing many important problems coupled with the proposals for changes in her political status within the British Commonwealth. In spite of attempts to encourage her younger people to emigrate and to persuade countries such as the United States, Australia and New Zealand to accept more Maltese, the inhabited islands, which comprise Malta,

Gozo and Comino, are some of the most densely populated in the world. (The inhabited islands are 121 square miles in extent, and these house a population of 314,000.) Malta will be profoundly affected by the proposed cuts in the British Armed Forces, and she has already been warned of a reduction in civilian personnel in her Dockyard, which has, hitherto, been her main economic prop. Owing to the nature of the islands and the seas around, agriculture and fisheries—her main industries—are difficult, and forestry presents problems unfamiliar to those used to more fertile and deeper soils. The present Government is making considerable efforts to get more industries started—sponsored either by the State or by private enterprise. Education in this densely populated area is therefore of paramount importance, not only to Malta herself but also to the Commonwealth.

It may surprise some people to learn that compulsory education was not introduced into Malta until after the Second World War (March 1946); but the Crichton-Miller Report reveals that great strides towards improvements have been taken since then, especially by the present Government. Naturally, considerable difficulties were met in implementing the policy of compulsory education, especially during its initial stages. This was due mainly to the rising child population, which was increasing at the rate of a thousand a year in an area of a total population of 314,000. Indeed, up to so recently as September 1954, only 561 out of a total of 1,777 primary school classes were receiving full-time education in their own class-rooms.

Primary Education

A very determined scheme which was begun in March 1955 saw the eradication of all part-time work—as the Report indicates, "a truly remarkable achievement". Credit for this must be given to the present Government of Malta and especially to the Minister of Education, the Hon. Agatha Barbara, and to the Director of Education, Mr. J. P. Vassallo.

Mr. Crichton-Miller expresses his conviction that the children are now housed in such a way that teaching can be carried out with almost the maximum efficiency. This, coupled with the Government's most recent Financial Statement that the building of new schools is to be accorded priority, must be gratifying to those most closely concerned. There are now 120 government primary schools and many private elementary schools. At present there are about 53,000 children in the government schools, and soon the authorities will be faced with the problem of distributing annually about 10,000 children who, at the age of 11–12 years, have completed a comprehensive course of primary education. It seems, however, that the Government's prodigious efforts at improving educational opportunities and standards are much favoured by children who are by nature very intelligent, and whose manners and discipline are above average (due to home and church influences), and by parents who are co-operative.

The children are admitted to the primary schools at the age of six, and the Report gives cogent reasons for not reducing this to five, as in Great Britain. The Report also advocates a short junior secondary course of 2–3 years duration in the present primary schools proper. Such a course, followed by a certificate examination in English and possibly arithmetic, might prove helpful to such school leavers when applying for work. Children may leave school at the age of fourteen, and the Report does not support the idea that the school-leaving age should be raised to fifteen, though pupils should be allowed to stay on at school on a voluntary basis.

A 'compulsory control examination' at the end of the primary school age is recommended. This would correspond to the so-called 'eleven-plus' examination in Britain; but a two-year range is suggested for Malta. Thus the bright child would gain early promotion, whereas the slower child would get a second chance. Following this examination, children would be drafted to secondary grammar, secondary technical or secondary clerical courses, or they would take the 'short secondary' course mentioned above. Thus the present special arrangements for the preparation of Dockyard candidates would be eliminated—arrangements which Mr. Crichton-Miller, in any event, deplores. Moreover, if a control examination is introduced, it would be unnecessary to include in the primary syllabus any special training of candidates for the Lyceum in Valetta.

Higher and Technical Education

Considerable developments have recently been made in secondary education, and new training colleges are being developed for which the Government has obtained financial assistance from various sources. At present there are six secondary schools (one of them preparatory) and two technical schools, apart from the Lyceum. New buildings, especially for the Lyceum in Valetta, are in an advanced stage.

The general aim is to provide for 5,000 pupils in the Lyceum and a girls' school (both of grammar school status), senior and junior technical schools and a girls' clerical college. These will be in Malta, and a similar provision on a smaller scale will be made in Gozo. The Report maintains that this aim is not too ambitious, provided that the primary schools supply the candidates of the requisite standard.

The main problem here is the provision of a sixth form, for staff will be required, and the parents will have to be persuaded to use it. In this connexion, a great deal depends on the Royal University of Malta, because at present its students on entry have not done the kind of post-certificate course with two-advanced-level subjects as is demanded by most universities. It is claimed that if the University demanded a sixth-form standard in its freshmen, then parents would eventually recognize the value of such a sixth form.

If and when a sixth form becomes established in the secondary schools, the main problem to be faced will be its content. In the past, science subjects have been neglected. This is ascribed by some to the shortage of science teachers. But according to the Report, this is not the only reason, because the children of Malta go in for the study of languages more than do those of any other country in Europe; in fact, it is not unusual to find a pupil in a grammar school studying as many as five languages. In view of this, Mr. Crichton-Miller goes so far as to suggest that in the new science sixth forms, cultural subjects should be virtually excluded if the production of high-class scientists and technologists is not to be

prejudiced at university entrance-level. It appears, therefore, that the only institution in Malta which could maintain a comprehensive sixth form offering science and arts subjects, as understood in the average large British grammar school, would be the Lyceum. The Report also suggests that the other secondary schools should specialize in their sixth forms in either arts or sciences, or languages, etc.

The suggested 'clerical' grammar schools will cater for children who do not intend proceeding to the University, so these schools will have no sixth form. Their certificate examination will be at the ordinary level and will embrace more commercial subjects. Nothing has so far been done towards the development of such schools.

The supply of skilled craftsmen and technicians is being taken into careful consideration; in fact, even at the level of ordinary secondary education, there are to be schools having a technical bias. Some pupils will drop out of such schools at the age of fourteen, and go straight to trade apprenticeships, whereas others will proceed to a senior technical school. A polytechnic school is also being planned.

The secondary school-leaving age is to be 15–17. Most of these school leavers will go straight into employment, though some of them will continue part-time studies, mainly on the technical side. The rest will continue their education (1) overseas; (2) at a teachers' training college; (3) at the polytechnic (when ready); or (4) at the Royal University of Malta. Those who proceed to a British or other university will be ensured of a satisfactory advanced education. The proposed scheme for a polytechnic is still uncertain, but will no doubt develop as the demand grows.

The Report envisages about 150 students wishing to gain admission to the Royal University of Malta; but, alas, the University is at present in no position to cope with such a demand. In fact, it is suggested in the Report that the University should be subjected to complete re-organization if it is to play its part in the quickly developing educational scheme in Malta. It is not possible at this stage to make any constructive suggestions, though the Report does hint at the need for extra-mural advice. The University is autonomous, but looks mainly to the Government for its funds, so it is only natural that the Government should wish to know what it is paying for*.

It is obvious from the Crichton-Miller Report that the main shortcomings in education in Malta lie in the lack of sixth forms in the secondary schools and in the general organization of the University. It is curious that the development of education in Malta since school education became compulsory is starting from the primary schools, whereas in Britain and elsewhere it has been the universities which originally set the pace.

Aims and Objectives

The aim of the present large-scale programme of educational development in Malta is threefold: (1) to give the people one of the fundamental benefits of the Welfare State; (2) to supply a training ground at home for future leaders; (3) to raise a class of skilled technicians which will stimulate industry in Malta and produce more types of would-be emigrants who would be most welcome in other lands—because, in this thickly populated area, emigration is of prime importance.

It is clear that training for leadership is out of the question until there is a sixth-form system as a regular source of high-grade students for the University, and on the technical side, the proposed polytechnic will play an important part.

One of the most difficult problems to face in this connexion is the fact that Malta cannot at present provide its own secondary school teachers having the desirable academic qualifications. Therefore, to make the country self-sufficient, a good teaching staff must be a priority target, for the Report states that the salaries are adequate.

A Director of Technical Education has been appointed, because the present Government's plans for technical education are ambitious—and rightly so if Malta is to develop industries of her own and produce emigrants who are able to qualify for membership of the craft unions in Great Britain, Australia or the United States. The proposed polytechnic will provide for whole-time courses, 'sandwich' courses and a large range of continuation classes. At first, examinations in this institute will be for the national certificates, City and Guilds diplomas, and membership of the various engineering institutions; eventually degrees courses in the polytechnic might be instituted. It is significant that the Dockyard Authorities are anxious that skilled workers for new industries in Malta should be trained outside the Dockyard, for they have no wish to hold a monopoly in this sort of education.

Mr. Crichton-Miller expresses the opinion that the considerable educational developments in Malta have already gone far in the right direction and the future standards aimed at are commendably high. But he qualifies this by emphasizing: the marked deficiency on the academic side and the need for reform in the University; the rather indefinite aspirations governing the rapid development of technical education, and the obvious risk involved in training craftsmen for whom there is, at present, no suitable work; the need for a more convincing effort to show that this great expansion in the educational services has not been done too hurriedly. He concludes his Report, however, as follows: ". . . when the foundations are so good, and the design so promising, the critic is inclined to judge by the highest standard. This is the best tribute I can pay to those who have worked so hard, and with such vision, during these last two years".

* It is encouraging to learn that the Government and the University, with the assistance of the Inter-University Council for Higher Education Overseas, are to form a mission comprised of certain authorities from Great Britain and others from the Royal University whose function it will be to tackle the serious problems involved. This mission is about to start its work.

THE INSTITUTION OF CHEMICAL ENGINEERS

ROYAL CHARTER

THE foundation of the Institution of Chemical Engineers in 1922 was inspired by the experiences of the First World War. By the beginning of this century, Britain had fallen behind other countries, notably Germany, in the development of heavy

chemical industry. The outbreak of war was rapidly followed by a serious shortage of munitions, and the attention focused on the design, construction and efficiency of plant for the manufacture of explosives led to a vigorous campaign by Lord Moulton for the training of chemical engineers. The industrialists, chemists and engineers who founded the Institution realized that the design and operation of chemical plant needed its own engineering discipline, and it was agreed that a new qualifying professional body was essential to organize the study of the new technology.

The emphasis on qualification was important because at that time no university in Britain offered courses in the subject, whereas in the United States courses in chemical engineering had been started at the Massachusetts Institute of Technology as early as 1888, and by 1920 there were 5,743 students of the subject in American universities. The key to the recognition of the distinct qualities of chemical engineering was the publication of a text-book by Prof. W. K. Lewis and the staff of the Massachusetts Institute of Technology, where the teaching of chemical engineering followed the lines first proposed by the English pioneer, G. E. Davis. This used the concept of 'unit operations', whereby the large-scale chemical manufacturing processes were analysed according to the fundamental physical principles involved: fluid flow, heat and mass transfer, rate-processes and thermodynamics.

From the beginning the Institution set a high standard for its qualifications. The examination devised was unique and still retains the original essentials, which might well be a model for developments in other fields. The examination is divided into two parts, the first conducted by conventional written papers in the theory and practice of the subject, and the second a problem in design which the student is allowed two months to complete. This amounts to more than a test: it affords training in the organization of material which has to be sought in the original papers and patents as well as in the text-books. The student who completes it has learnt to derive practical engineering solutions to problems for which the data are scattered and incomplete.

These qualifying functions of the Institution are still of the first importance, although the task of examining students has been lightened by the growth of degree, diploma and postgraduate courses in chemical engineering in British universities and colleges of technology, and by the courses for the Higher National Certificate. Courses for the training of chemical engineers are now offered in more than twenty colleges in Britain. Chairs in the subject exist at University College and the Imperial College, London, and at Birmingham, Cambridge, Durham, Edinburgh, Glasgow, Manchester and Swansea, and there are departments which include chemical engineering at the Universities of Leeds and Sheffield. More than three hundred degrees are awarded annually.

The membership of the Institution has grown continually over the years, to the present number of 3,500. In the United Kingdom, branches of the Institution operate in the Midlands and the North-West, and there are informal groups in Scotland, Scunthorpe and South Wales. In South Africa there is a strong branch, and advisory panels operate in Australia, India and New Zealand. The examinations of the Institution attract entries from all over the Commonwealth, and are normally held in Australia, Canada, India, New Zealand, Pakistan, South Africa and the West Indies as well as in Britain and Holland. The steady stream of Dutch candidates is witness to the need for the qualification and the esteem in which it is held in Europe.

Although more than half the membership of the Institution is employed in the chemical industry and in the manufacture of chemical plant, a wide distribution is to be found among a range of industries characterized by their high rate of capital investment, such as the textile industry. An analysis of the functions of chemical engineers within these industries, carried out by the Institution, shows that more than four-fifths are divided about equally between administration; plant operation, production and maintenance; plant design, construction and installation; and research and development. The remaining fifth are occupied in technical sales and services, teaching, consulting, etc.

The demand by industry for chemical engineers has outstripped the facilities offered by the universities and the special courses leading up to the Institution's examination. A start has been made with Higher National Certificates in chemical engineering at a number of technical colleges, and efforts are being made to expand the facilities. The Institution has co-operated with the Ministry of Education in the preparation of a model syllabus, in the moderating of examinations and by the recognition of the Higher National Certificate with an endorsement as exempting a candidate from the first part of the Institution's examination. It is of the first importance to the British economy, not only that these facilities should be enlarged, but also that an adequate supply of recruits to the profession from the schools should be maintained. To attract and inform potential engineers, the Institution has recently issued an illustrated booklet* describing the work and prospects of the chemical engineer, the qualifications and methods of training, and the industries in which he is engaged, for distribution to schools on request.

As part of the work of a professional body, the publication of original papers is an important activity of the Institution. Its *Transactions*, which are now published bi-monthly, contain original communications of research carried out in universities, in industry and at research associations. The papers cover fundamental investigations into the basic mechanisms of fluid flow, heat and mass transfer and thermodynamics, applied research on industrial problems, and questions of safety, economics and management. The *Transactions* are distributed to members of the Institution and to libraries, universities and industries throughout the world.

The rapid growth of the processing industries such as oil refining, chemicals, artificial fibres and plastics has created a demand for chemical engineers which is not satisfied. The development of new industries, based on nuclear energy and the processing of fissile material, has added to this demand. The mounting appreciation of the importance of the 'fourth primary technology' to the nation's economy and the status of the Institution of Chemical Engineers have been confirmed by the recent grant of a Royal Charter to the Institution (*Nature*, **179**, 947; 1957), which may look forward to an assured role in the development of British industry.

* Chemical Engineering: a Career. Pp. 31 (12 plates). (London: Institution of Chemical Engineers, 1956.) 2s.

EAST AFRICAN AGRICULTURAL AND FISHERIES RESEARCH COUNCIL

REPORT FOR 1956

THE annual report of the East African Agricultural and Fisheries Research Council* for the year ended June 30, 1956, comprises a general review and the separate reports of the Organizations for Agricultural and Forestry Research, for Veterinary Research, for Fishery Research, for Marine Fisheries Research, and for Trypanosomiasis Research, each of which includes a list of staff and of papers published during the period. A Trypanosomiasis Research Co-ordinating Committee was established during the year and it is believed that co-ordination is now adequate. Generally, the East African Agriculture and Forestry Research Organization gives preference to problems of immediate importance to more than one territory, which require several years research, and to problems requiring both a central research team or co-ordinating research officer and territorial field officers. Forestry nursery work has been very successful in developing improved methods of managing tree seedlings. Experimental work on the conservation of water by fallows at Kangwa has been completed and the first stage of the work on assessing the fertilizer needs of a soil is nearing completion; an investigation is to be undertaken of factors which influence the rate of oxidation of organic matter in tropical soils. A revised edition of the Soil Map of East Africa is in preparation and work continued on the genetical analysis of the resistance of maize to American rust disease. The survey of insects attacking East African forest trees has been largely concerned with wood-boring species, while studies of the digestibility of protein in fodders have shown that within narrow limits there is a unique relation between the crude protein content of a feed and its apparent digestibility and that this relation is the same for all ruminants.

Substantial progress was made in the establishment of the East African Veterinary Research Organization and production of caprinized and leprinized rinderpest vaccines was not seriously interrupted. A satisfactory technique for producing high-quality pleuropneumonia antigen was devised using a new tryptose broth medium and a modified Lister separator for concentrating the organisms.

The annual report of the East African Marine Fisheries Research Organization for 1955–56 reviews briefly the work of the previous four years. A preliminary report on the distribution in place and time of the pelagic fishes will be published shortly, but this study still requires a long series of patient observations and its scope is being extended.

The East African Trypanosomiasis Research Organization was almost at full strength for the first time in 1956. It can now be affirmed that *G. morsitans* and *G. swynnertoni* normally find most feeds from wart-hog, seldom, if ever, from zebra and hartebeest, and very rarely from impala; but given the opportunity *G. morsitans* takes the greater part of its feeds from hippopotamus. In general, research on the trypanosome in East Africa is far behind that on the tsetse fly, and a chief problem is the extremely complex problem of the 'trypanosome challenge'. At the Central Trypanosomiasis Research Laboratory the whole life-cycle of trypanosomes, particularly those of the polymorphic group, is under investigation, but three of the larger projects are epidemiological investigations. The pilot schemes for tsetse reclamation are being wound up and the Organization will no longer include that field among its activities.

The annual report of the East African Fisheries Research Organization* for the year ended June 30, 1956, includes a list of publications by its staff and by visiting scientists and a paper on "The Efficient Utilization of the Fisheries of Lake Victoria", setting forth the views of the Organization on retention of the existing restrictions on fishing. Appendixes include papers on the distribution of sulphur in the muds, water and vegetation of Lake Victoria and its fixation in the bottom deposits; observations on seasonal and diurnal changes of stratification in Lake Victoria; the planktonic Crustacea of Lake Victoria; effects of D.D.T. on the feeding habits of insectivorous fishes in the Victoria Nile; ring formation in the scales of *Tilapia esculenta*; and a preliminary note on investigations being undertaken on the physiology of reproduction in fishes. Studies on the water of Lake Victoria were severely handicapped by the absence of a hydrologist, but work on the food and feeding habits of piscivorous and insectivorous fishes in Lake Victoria is near completion. An investigation was started on the growth-rate and general ecology of young *Clarias messambicus* in the first two years of life, and research on the taxonomy and ecology of the seventy *Haplochromis* species in Lake Victoria is virtually complete.

* East Africa High Commission. Annual Report of the East African Agricultural and Fisheries Research Council, 1955–1956. Pp. ii+56. (Nairobi: Government Printer, 1957.) 8s. 3.

* East Africa High Commission. East African Fisheries Research Organization. Annual Report 1955/1956. Pp. vii+23. (Jinja, Uganda: East African Fisheries Research Organization, 1956.)

TECHNICAL COLLEGE LIBRARIES

UNDER the title "Standards for Library Service in Colleges of Technology", a Committee of the Sub-Section for Colleges of Technology and Further Education, University and Research Section of the Library Association, under the chairmanship of L. L. Ardern, has compiled a useful report* containing basic recommendations for libraries in colleges of advanced technology, regional technical colleges and those area technical colleges which have advanced full-time or sandwich courses. The report sets out to give broad guiding principles based on the experience of its members, and the minimum standards set forth should not only be of assistance to local education authorities, principals and others, including librarians engaged in the provision of libraries, but should also indicate how much remains to be done before technical college libraries can assume the regional functions that have lately been suggested for them.

The principal recommendations comprise appointment of a suitably experienced chartered librarian, with the status recommended by the Library Association Council, before the library is planned, and sufficient full-time staff to ensure that the library can

* Standards for Library Service in Colleges of Technology: a Report compiled by a Committee of the Sub-Section for Colleges of Technology and Further Education, University and Research Section, The Library Association. Pp. 16. (Cardiff: Mr. J. Fry, Librarian, College of Technology, 1957.) 3s. 6d.

remain open during college hours. A central library rather than departmental libraries is recommended: the latter should be provided only for distantly situated departments and should even then be under the control of the librarian. Seating accommodation should be adequate for 10 per cent of the student population, each part-time student being counted as one-fifth, and as a working formula it is recommended that the number of seats should be multiplied by twenty-five, with 20 per cent added to the product, to give the floor area in square feet, allowing for a librarian's office working space. Further allowance is required for book storage and future expansion.

The initial grant should be sufficient to provide for 10,000 volumes, with a minimum requirement after five years of ten volumes per student, and there should be retrospective files of the major technical periodicals. Alternative formulæ for this book fund are given, and the furnishings should include visual filing systems, internal and external telephones, noiseless typewriters, photocopying apparatus and a microfilm reader. A recognized classification scheme should be adopted and the catalogue should provide an accurate, consistent and up-to-date means of locating the book stock and its contents.

How far these standards are at present from being generally achieved is shown by an analysis subsequently issued by the Sub-Section and compiled chiefly from data for 1955–56 supplied by members of the Sub-Section. Completed returns were received from only forty-three colleges and the data are arranged in four divisions: large colleges with about one million student-hours, two-thirds being full-time; those with 500,000 student-hours, one-third full time; small colleges, with 250,000 student-hours, most part-time and evening; and monotechnics, usually smaller institutions teaching only one subject.

Of the large colleges, the six with the largest expenditure averaged only £2,740 annually on books and periodicals (compared with an average of £4,867 for six small university colleges and £2,000 recommended by the London and Home Counties Regional Advisory Council for Higher Technological Education) and the six with the smallest expenditure averaged only £706. The six with the largest expenditure averaged 27,625 books in stock, compared with 9,995 for the six with the smallest, 83,433 for the university colleges, and the 15,000 volumes recommended. The number of periodicals taken averaged 359 for the six with the highest and 125 for the six with lowest expenditure, the corresponding numbers of staff being six and two, respectively. With the latter figure, it is pointed out, a college library can only be manned, not staffed. For the medium colleges, the average figures for the four with highest and the four with the lowest expenditures are as follows: annual expenditure on books and periodicals, £1,065 and £513, respectively, compared with a recommended £1,000–£1,750; books in stock, 13,247 and 6,472, compared with 8,000–10,000 recommended; periodicals taken, 150 and 120; and staff in the four with the highest expenditure averaged only one, compared with a minimum of two recommended. While it is pointed out that expenditure on books needs improvement, the staffing problem is again the most vital. Although many technical colleges are well served by their single librarian, such provision cannot give real service to an institution.

THE SURFACE FREE ENERGY OF ICE

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THE surface free energy of ice is an important parameter in the theory of homogeneous nucleation of ice from supercooled water and in the theory of ice crystal growth from the vapour phase, but no direct experimental determination of its value is at present available. It is of interest, therefore, to estimate the work of cohesion across the basal $(000\bar{1})$ and prism $(10\bar{1}0)$ faces of a single crystal of ice using the Rowlinson[1] model of the water molecule.

When an ice crystal is cleaved along a basal or prism face a molecule bonded to either surface loses one nearest molecular neighbour and three or four next nearest neighbours, respectively. A molecule which is not hydrogen-bonded across the cleavage surface loses three next nearest neighbours if it lies in the basal plane or two if it lies in a prism face. Such bonded and unbonded molecules occur in pairs in both $(000\bar{1})$ and $(10\bar{1}0)$ planes; taken together they may be regarded as losing one nearest and six next nearest neighbours in either case. The energy per hydrogen-bond required for cleavage is thus $E_C = U_1 + 6U_2$, where U_1 and U_2 are the average interaction potentials between molecules in the first and second co-ordination zones, respectively, the attraction of more distant molecules being taken as negligible.

The interaction potentials U_1 and U_2 for intermolecular spacings of 2·76 A. and 4·51 A., respectively, have been calculated using Rowlinson's force constants, in which account is taken of dispersion, induction and multipole forces, up to and including terms varying as r^{-6} (Table 1). For both basal and prism faces the calculated energy E_C is thus 6,080 calories per mole surface. Expressed per unit area this free energy represents the work of cohesion $W_C^s = \frac{E_C J}{N_A s}$, while the surface free energy $F = \frac{W_C}{2}$, where J is the mechanical equivalent of heat, N_A is Avogadro's number, and s is the area of surface per hydrogen bond. From the geometry of the ice lattice the area per bond in the basal plane is given by $\frac{a^2\sqrt{3}}{2} = 1{\cdot}77 \times 10^{-15}$ cm.^{2} ($a = 4{\cdot}51$ A.), whereas the bond area in the prism face is $\frac{ac}{2} = 1{\cdot}66 \times 10^{-15}$ cm.^{2} ($c = 7{\cdot}35$ A.). Thus the prism faces are the more densely populated and their surface energies are slightly higher. The works of cohesion and corresponding surface free energies are found to be:

Basal plane $(W_C)_B = 238$ erg/cm.^{2}; $F_B = 119$ erg/cm.^{2}

Prism face $(W_C)_P = 256$ erg/cm.^{2}; $F_P = 128$ erg/cm.^{2}

Table 1. Potential Energy of One Molecule in Ice at 0° C. (cal./mole)

Due to a molecule in:	Multipole energy	Induction energy	Dispersion-overlap energy	Total potential
1st co-ordination zone	4,305	147	492	$U_1 = 4{,}944$
2nd co-ordination zone	74·3	—	115	$U_2 = 189{\cdot}3$

These values are probably somewhat too high, because molecules exposed at the surface on cleavage will tend to relax into new equilibrium positions and the energy released in the process will serve to reduce the work of cleavage. The surface distortion of the ice lattice will, however, be largely absent in a crystal that is immersed in water. An approximate value for the difference σ between the surface free energies of ice and water is obtained by setting $\sigma \simeq \frac{L_f}{2} \cdot \frac{J}{N_A s}$. Since the latent heat of fusion, L_f, is 1,430 cal./mole, we find $\sigma = 28$ erg/cm.[2] at 0° C. Some support for this estimate is provided by Fisher *et al.*[2], who calculated σ at − 38° C. from the results of experiments on the spontaneous freezing of supercooled water, using the theory of homogeneous nucleation. They conclude that $\sigma = 32$ erg/cm.[2].

The surface tension of supercooled water has not been measured below − 22° C., but extrapolation of the curve obtained by Hacker[3] gives for − 38° C. the value of $F_{water} = 84$ dynes/cm. At that temperature, therefore, $F_{ice} = 84 + 32 = 116$ erg/cm.[2], in good agreement with the calculated surface free energy for the basal plane.

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[3] Hacker, P. T., *N.A.C.A.* Tech. Note No. 2510 (1951).

INCORPORATION OF RADIOACTIVE AMINO-ACIDS IN THE PROTEINS OF BULL SPERMATOZOA

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It is widely held that ribonucleic acid is directly involved in protein synthesis, and there have been several recent demonstrations of the necessity for the presence of ribonucleic acid during synthesis of proteins[1]. In view of this, it seemed to be of interest to examine protein turnover in mature, ejaculated spermatozoa, which apparently contain at most only traces of ribonucleic acid. Several investigators[2–4], using different methods of analysis (chromatography and ionophoresis of the bases and nucleotides, and estimation of ribose as furfural), have been unable to obtain the specific ribonucleic acid components from human and ram spermatozoa or from heads of fish spermatozoa. The absence of the acid from bull semen has been confirmed in the present investigation. These observations are supported also by cytochemical evidence[5]. This report describes the results of preliminary experiments on the incorporation of ^{14}C-labelled amino-acids into the proteins of bull spermatozoa and seminal plasma.

The semen, within an hour of collection, was divided into equal parts, one for each time-point. The spermatozoa were separated by dilution with Krebs's bicarbonate buffer (*p*H 7·2; 4·5 per 1·4 ml. semen; the quantities given later in the text are for this amount) and mild centrifugation. The washed cells were suspended in the above buffer (4·5 ml.) containing 5 per cent fructose (w/v) and incubated at 37° in a Warburg bath under oxygen + carbon dioxide (95 : 5), with a mixture of uniformly-labelled amino-acids obtained by hydrolysing ^{14}C-*Chlorella* protein (1·185 μc. in 0·05 ml., from 22·5 μgm. protein). In one experiment, the supernatants containing the diluted seminal plasma were also incubated similarly. At appropriate intervals, samples were taken for cell count and motility determinations, and proteins were precipitated with 30 per cent trichloracetic acid (2 ml.). A solution of non-radioactive amino-acids (250 μgm.) was added, and the proteins were purified and rid of radioactive contamination, nucleic acid and lipids as described by Simkin and Work[6]. The proteins were plated as a slurry in 30 per cent alcohol and counted on an end-window counter giving 1,000 counts/min. with a 10^{-3} μc./mgm. carbon standard of infinite thickness on 1 sq. cm. The results are given in Table 1 and Fig. 1.

For determination of ribonucleic acid, 1 ml. of semen (containing 2·91 mgm. of deoxyribonucleic acid on the basis of an average deoxyribonucleic acid content[7] of $3{\cdot}04 \times 10^{-9}$ mgm./cell) was diluted and precipitated with trichloracetic acid at 0°. After washing and removing lipids, the protein–nucleic acid mixture was hydrolysed with 1 *M* perchloric acid at 4° for 21 hr. and ribose was estimated in the supernatant by the orcinol method. In this way, a value of 9·6 μgm. ribonucleic acid/mgm. deoxyribonucleic acid was obtained for the semen; this value is within experimental errors and is too low to be

Table 1

Time (min.)	Washed spermatozoa			Seminal plasma
	Cell count* ($\times 10^6$)	Motility (arbitrary units)	Protein yield‡ (mgm.)	Protein yield (mgm.)
14	9·14	++	10·5	21·3
60	10·43	++	7·55	24·7
120	9·20	++†	7·05	25·7
180	9·43	+	6·0	22·7
240	—	occasional	5·6	24·6
300	—	none	6·8	22·2

For each time-point 1·4 ml. semen was used (Exp. 2, Fig. 1); protein yields refer to the initial amount of semen

* Per ml. semen.

† Motility of spermatozoa in semen at room temperature was ++++ at this time.

‡ In another experiment (Exp. 1, Fig. 1) with 2·8 ml. semen and using 2·37 μc. carbon-14 for each time-point, the protein yields at 3, 10, 30 and 60 min. were 30·3, 26·7, 23·0 and 17·3 mgm., respectively.

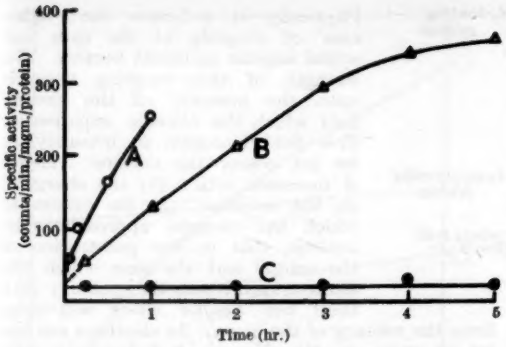

Fig. 1. Incorporation of radioactive amino-acids in the proteins of spermatozoa and seminal plasma. *A* and *B*, spermatozoa proteins in Exps. 1 and 2, respectively; *C*, seminal plasma proteins (Exp. 2). Broken lines are extrapolated. Also see legend to Table 1

significant. It is possible that the 'cytoplasmic droplets'[2] found in semen may contain a trace of ribonucleic acid[8]. The proteins of the seminal plasma, which is likely to have retained these droplets and is known to be rich in enzymes, in fructose and in amino-acids, did not incorporate any radioactivity (Fig. 1).

It will be noticed from Fig. 1 and Table 1 that the rate of incorporation of amino-acids in the spermatozoa falls with time, almost in parallel with the fall in their motility. From the data given on the specific activities of the carbon-14 amino-acid mixture and the isolated proteins, it may be calculated that in Exp. 1 the rate of radioactive amino-acid incorporation in the spermatozoa was 0·12 μM/gm. protein/hr. In the experiments reported here, the radioactive amino-acid concentration in the incubation medium was about 0·05 μM/ml. With a much higher concentration of labelled amino-acid (1 μM/ml.), rat diaphragm cells, rabbit reticulocytes and rabbit bone marrow cells incorporate 0·10, 0·89 and 1·5 μM of labelled amino-acid/gm. protein/hr., respectively[9]. Thus bull spermatozoa seem to have a fairly high rate of protein turnover, and since these cells are virtually devoid of ribonucleic acid, this strongly suggests that ribonucleic acid is not essential for protein synthesis in these cells. This, it should be emphasized, is not completely incompatible with the excellent correlation between protein synthesis and ribonucleic acid obtained in other cells.

These observations are particularly interesting in view of the unique function of the spermatozoa. It is possible that in this case deoxyribonucleic acid may be involved in the synthesis of proteins. Some recent observations, for example, on protein synthesis in isolated calf thymus nuclei[10], would support this view. Such a finding, however, would be unexpected in spermatozoa as the deoxyribonucleic acid of these cells is in a dehydrated form and therefore has been regarded as metabolically inert. The other possibility would be to regard protein synthesis in spermatozoa as an enzymatic process independent of nucleic acids. It is hoped that the work now in progress will throw some light on this issue.

The data in Table 1 suggest a gradual loss of cell proteins during incubation, the rate of loss decreasing with time. It is possible that the high rates of incorporation of amino-acids on one side, and of protein loss on the other, may be related, and in fact, as suggested by Simpson[11], may be taking place through a common mechanism.

I am greatly indebted to Dr. T. S. Work for his interest and much helpful advice, and to Drs. M. W. H. Bishop and C. R. Austin, whose work on germ cells stimulated this investigation and who also provided the bull semen and determined the spermatozoa counts. The Wellcome Trust is also thanked for a Research Fellowship.

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MAGNETIC BEHAVIOUR OF THE IRON–RUTHENIUM–OSMIUM TRIAD

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IT has been widely recognized by physicists[1] during the past decade that unusual magnetic behaviour among the transition metal complexes can be understood better in terms of the ligand (crystal) field theory than in terms of the more usual Pauling[2] approach. However, although the ligand field theory has been increasingly applied by chemists[3,4] to the study of spectra and stereochemistry, its use by them in connexion with magnetic properties is less common, although its importance has been stressed[3]. This neglect has led to some misinterpretation of the magnetic behaviour of certain complexes, principally of the second- and third-row elements. In this article we seek to summarize the importance of the ligand field theory in explaining the magnetic moments of those six-covalent transition metal complexes in which so-called 'inner' orbital bonding occurs, as a basis for interpreting the magnetic

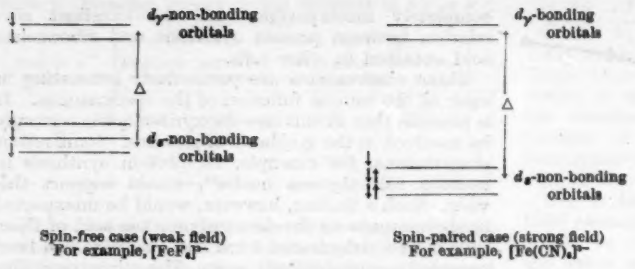

Fig. 1

behaviour of the various valency states of iron, ruthenium and osmium.

When six octahedrally distributed negative charges (that is, ligands) are placed about a transition metal ion, the effect can be looked at from two points of view. Either one may concern oneself with the actual occupation of *d*-orbitals by the non-bonding *d*-electrons, or one may examine the effect of the ligand field upon the spectroscopic state of the ion. In connexion with the first of these approaches, it is well known that the five *d*-orbitals split in the presence of an octahedral (cubic) field so that there is a lower degenerate triplet (d_ε-orbitals) and an upper degenerate doublet (d_γ-orbitals). The separation (Δ) between these levels is of the order of 10,000 cm.$^{-1}$ in a weak field (for example, in $[Fe(H_2O)_6]^{++}$) and 30,000 cm.$^{-1}$ in the case of a strong field (for example, in $[Fe(CN)_6]^{4-}$). In practice, slight deviations from perfect octahedral symmetry usually means that the members of the d_ε-triplet levels and the d_γ-doublet are split slightly apart. Fig. 1 illustrates the situation operating in the above two ions.

The effect of an octahedral field upon the magnetic moment of an ion depends upon the spectroscopic state of the ion. Thus the Fe II ion in the field-free condition is in a *D*-state ($^5D_4$) and when subjected to a cubic field due to an octahedral arrangement of six negative charges, this level is split into a lower triplet and an upper doublet. It is the near degeneracy of the three lower levels which gives rise to orbital contribution to the magnetic moment in ferrous compounds. Thus, for $[Fe(H_2O)_6]^{2+}SO_4.H_2O$, $\mu = 5{\cdot}4$ Bohr magnetons; the spin-only value is 4·9 Bohr magnetons. Complete or nearly complete destruction of the orbital contribution occurs when the splitting is such as to give a singlet-level (or a non-magnetic doublet) as the lowest lying state, providing it is separated from the next level by an energy interval $h\nu \gg kT$. This occurs, for example, in octahedral Ni II complexes, where the *F*-state is split into two upper triplets and a low-lying singlet.

However, in the case of certain complexes of the heavy transition metals, μ is even less than the value expected for the spin-only moment on the Pauling theory; for example[5], for K_2OsCl_6, $\mu = 1{\cdot}4$ Bohr magnetons at 20° C., whereas a value corresponding to two unpaired electrons (2·83 Bohr magnetons) would have been anticipated. The reason for this apparent anomaly arises from the high value of the spin-orbit coupling constant A, in the second- and third-row transition metals.

The spin-orbit coupling constant A may be regarded as a measure of the mean energy separation between successive possible values of J for the field-free atom. Physically it indicates the 'tightness' of coupling of the *spin* and *orbital* angular momenta vectors. The strength of this coupling depends upon the intensity of the electric field which the electron experiences. This field increases in intensity as we get nearer the nucleus. Hence A increases with: (1) the charge Z on the nucleus; (2) the extent to which the electron approaches the nucleus, that is, the penetration of the orbital and the time which the electron spends near the nucleus; (3) a third but smaller effect will arise from the valency of the atom. As electrons are lost by an atom, so the electron shell becomes more concentrated (or vice versa) and this in turn affects the electric field to which the electron is subjected.

Magnetic results are collected for various spin-paired iron, ruthenium and osmium compounds in Table 1 with the number of non-bonding *d*-electrons varying from one to six. Some new values are quoted from our investigations. By applying the ligand field theory to the transition metal-complexes, Kotani[4] has deduced the variation of the effective magnetic moment with temperature and spin-orbit interaction for d_ε^n-configurations. Fig. 2 shows this variation for different electronic states of the central ion, in terms of the function kT/A, where k is the Boltzmann constant, T is the absolute temperature, and A is the spin-orbit coupling constant of the central metal ion. The theory predicts that only in the case of a d_ε^3-configuration, when there is no orbital degeneracy, will the moment correspond to spin-only value over the whole temperature-range; and for the other configurations the moment will be markedly dependent on the temperature and the spin-orbit interaction. In deducing these relationships, Kotani assumed a perfect cubic field and no interaction between neighbouring paramagnetic ions,

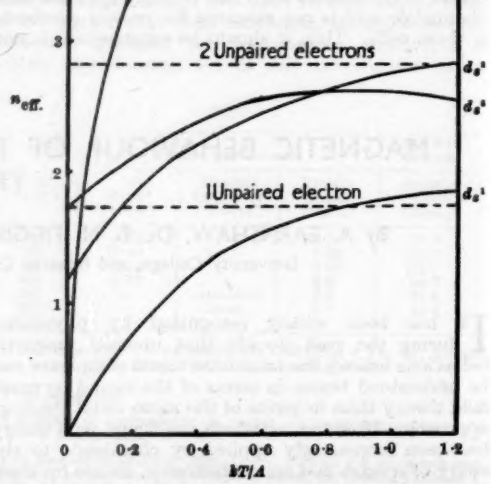

Fig. 2

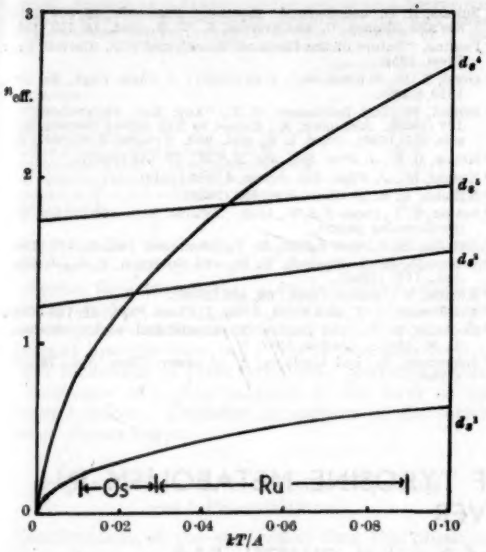

Fig. 3

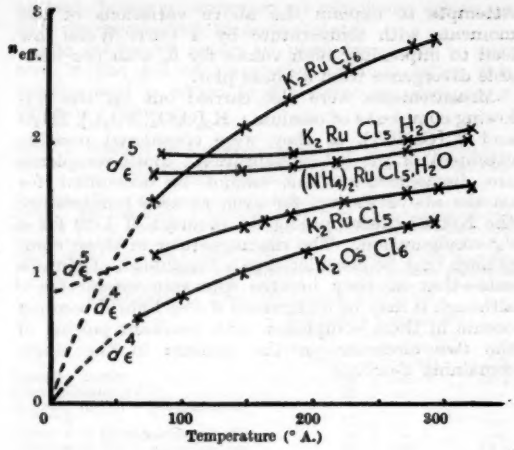

Fig. 4

that is, that the compounds did not exhibit any anti-ferromagnetic or ferrimagnetic interaction.

For the first-row elements, the value of A is of the order of 200–500 cm.$^{-1}$; at a temperature of 300° K. this gives values of kT/A of 1·04–0·42. Over this range, the magnetic moment would be expected to be constant for the d_ϵ^5- and d_ϵ^3-configurations, whereas a variation would be expected for the d_ϵ^1- and d_ϵ^2-configurations. With the second- and third-row transition metals, the value of the spin-orbit interaction is greater. Fig. 3 shows the variations in the magnetic moments over the ranges to be anticipated for ruthenium and osmium salts. Under these conditions, the maximum change is to be found for the d_ϵ^4-configuration. Table 1 gives observed values of the magnetic moments of some comparable salts of iron, ruthenium and osmium; as indicated by the Kotani theory, where variation in the effective moment occurs, the moments decrease in inverse order of the spin-orbit coupling constant; that is, osmium < ruthenium < iron. It is difficult to assess the effect that unsymmetrical substitution in an octahedral complex will have on the magnetic moment, as this will impose an unsymmetric field on the central metal atom, which will lead to a different splitting of the various energy levels. This asymmetry may account for the departures of the results cited in Table 1 from the theory.

With first-row transition elements a variation in A occurs with changes in the oxidation state, and it may be expected that a similar, but perhaps smaller, variation will be observed for the second- and third-row transition elements.

Measurements of the variation of the moment with temperature have been carried out for some ruthenium and osmium complexes which are shown in Fig. 4. The complexes $K_2RuCl_5(H_2O)$, $(NH_4)_2RuCl_5(H_2O)$ and K_2RuCl_5 are examples of the d_ϵ^3-configuration. The hexachlororuthenates appear to agree with the theory, giving moments of 1·82 and 1·75 on extrapolation to zero temperature. The pentachlororuthenate has an estimated moment of 0·85 Bohr magneton at zero temperature; but as this is probably a bi-nuclear complex involving chlorine bridges, the low value may arise from metal–metal interaction. The hexachlororuthenate and hexachloroosmiate are examples of the d_ϵ^4-configuration. As indicated by the Kotani theory, there is a considerable variation in the magnetic moment of these complexes with temperature, and the effective magnetic moment was found to be proportional to the square root of the absolute temperature. Extrapolation of the moment to zero temperature gave a value of 0·08 and 0·00 Bohr magneton for the moments of the ruthenium and osmium complexes, respectively. These results agree with previous observations[14] on the complex K_2OsBr_6, and give A, the spin-orbit coupling constant, as 1,850 and 6,400 cm.$^{-1}$ for ruthenium IV and osmium IV, respectively.

Table 1

No. of non-bonding (n)d electrons	Magnetic moment for spin only (Bohr magnetons)	Fe (n = 3)		Ru (n = 4)		Os (n = 5)	
		Compound	Moment 300° K.	Compound	Moment 300° K.	Compound	Moment 300° K.
6	dia.	$K_4Fe(CN)_6$	dia.	$K_4Ru(CN)_6$	dia.	$K_4Os(CN)_6$ (ref. 13)	dia.
5	1·73	$[FeD_2Cl_2]ClO_4$ (ref. 7)	2·22	$[RuD_2Cl_2]ClO_4$ (ref. 8)	1·95	$OsD_2Cl_2ClO_4$ (ref. 8)	1·88
4	2·83	$FeD_2Cl_2^{++}$ (ref. 9)	2·98	$CsRuF_6$ (ref. 10)	2·8	K_2OsF_6 (ref. 10)	1·42
3	3·88	$NaFeO_2$ (ref. 11)	3·6	$KRuF_6$ (ref. 10)	3·6	$KOsF_6$ (ref. 10)	3·2
2	2·83	K_2FeO_4 (ref. 12)	2·83	—		K_2OsO_4 (ref. 13)	0
1	1·73	—	—	—		—	

Attempts to explain the above variations of the moments with temperature by a Curie–Weiss law lead to impossibly high values for θ, with considerable divergence from a linear plot.

Measurements were also carried out on the following complexes of osmium: $K_2[OsO_3(NO_2)_2]$, $3H_2O$ and $K_2[OsNCl_5]$, as they were considered possible examples of the d_ϵ^2-configuration. Both complexes are diamagnetic. This cannot be accounted for on the above theory, for even at zero temperature the Kotani theory predicts a moment of 1·22 for a d_ϵ^2-configuration. The diamagnetism in these compounds may be considered as a breakdown of Hund's rule—that is, they involve spin–spin interaction—although it may be understood if d^4sp hybrid-bonding occurs in these complexes, with resultant pairing of the two electrons on the osmium in the single remaining d-orbital.

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PHENYLALANINE INHIBITION OF TYROSINE METABOLISM IN THE LIVER

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During the course of investigations designed to throw further light on the factors influencing tyrosine breakdown to acetoacetate in isolated liver tissue, results have been obtained which indicate that L-phenylalanine exercises a considerable inhibitive action on tyrosine metabolism in liver slices.

Experiments were carried out with freshly cut rat-liver slices incubated in the presence of solutions of L-tyrosine, potassium α-ketoglutarate and sodium ascorbate at 37° in the conventional Warburg manometric apparatus. The acetoacetate formed was measured by addition of aniline at the end of incubation period, the citrate salt being used[1]. The carbon dioxide thus liberated was a measure of the acetoacetate produced. The salts of α-ketoglutaric acid and ascorbic acid were added to ensure optimal rates of acetoacetate formation[2].

Results recorded in Tables 1 and 2 show the effects of the addition of L-phenylalanine at different concentrations on acetoacetate production from L-tyrosine and L-glycyltyrosine when these are incubated with liver slices obtained from well-nourished male albino rats. Both L-tyrosine (2 mM) and L-glycyltyrosine (2 mM), under these experimental conditions, yield substantial increases of the rates of acetoacetate formation, the endogenous rate being almost doubled. The addition of L-phenylalanine (2 mM) brings about only a small rise (if any) in the endogenous acetoacetate formation. When L-phenylalanine is mixed with L-tyrosine, or with L-glycyltyrosine, in equimolar concentrations, the rate of acetoacetate formation from the latter amino-acids is diminished almost to the level found with L-phenylalanine alone. It is difficult to estimate the percentage inhibitory effect of L-phenylalanine on L-tyrosine breakdown from these results, as the endogenous acetoacetate formation is probably partly due to the oxidation of phenylalanine and tyrosine present in the liver cells.

The inhibitory effect of L-phenylalanine is unlikely to be due to competition for the α-ketoglutarate which brings about the preliminary transamination before oxidation takes place. This is shown by the fact that the addition of L-alanine (2 mM), which is known to undergo vigorous transamination with α-ketoglutarate in presence of liver tissue, exerts no inhibitory effect on the rate of acetoacetate formation in presence of L-tyrosine (see Table 1).

As is well known[4], liver homogenates bring about oxidation of L-tyrosine to acetoacetate[5]. Results given in Table 3 show that, when fortified with α-ketoglutarate and ascorbate, acetoacetate is formed from L-tyrosine in presence of a dialysed rat-liver homogenate. They show, moreover, that the addition of L-phenylalanine, which gives little or no aceto-

Table 1. Effects of L-Phenylalanine and of L-3.4-Dihydroxyphenylalanine on Acetoacetate Formation from L-Tyrosine and L-Glycyltyrosine in Presence of Rat-Liver Slices

Present in the Warburg vessel, besides the amino-acids, are the following: potassium α-ketoglutarate, 30 mM; sodium ascorbate, 1·7 mM; potassium malonate, 20 mM; Ringer-phosphate solution (0·13 M NaCl, 0·005 M KCl; 0·003 M $CaCl_2$; 0·001 M $MgSO_4$; 0·001 M KH_2PO_4; 0·01 M sodium phosphate buffer pH 7·4). Total volume, 3·0 ml.; atmosphere, oxygen

	Q_{Ac} (c.mm. acetoacetate formed per mgm. dry-weight tissue per hr.)
Endogenous	1·89
Tyrosine 2 mM	3·65
Glycyltyrosine 2 mM	3·39
Phenylalanine 2 mM	1·85
Tyrosine 2 mM + phenylalanine 2 mM	2·16
Glycyltyrosine 2 mM + phenylalanine 2 mM	1·80
L-3.4-Dihydroxyphenylalanine 2 mM	1·70
Tyrosine 2 mM + L-3.4-dihydroxyphenylalanine 2 mM	2·23
Tyrosine 2 mM + L-alanine 2 mM	3·44

Table 2. Effects of Varying Concentrations of L-Phenylalanine on Acetoacetate Formation from L-Tyrosine in the Presence of Rat-Liver Slices

Experimental conditions as in Table 1.

	Q_{Ac}
Endogenous	1·60
Tyrosine 2 mM	3·52
Phenylalanine 0·4 mM	2·24
Phenylalanine 1·0 mM	2·22
Phenylalanine 4·0 mM	1·90
Tyrosine 2 mM + phenylalanine 0·4 mM	2·65
" phenylalanine 1·0 mM	2·17
" phenylalanine 4·0 mM	1·98

Table 3. Effects of L-Phenylalanine and of L-3.4-Dihydroxyphenylalanine on Acetoacetate Formation (in Air) from L-Tyrosine and L-Glycyltyrosine in the Presence of 1 ml. Dialysed Liver Homogenate

	Acetoacetate formed in 100 min. at 37° (c.mm.)
Endogenous	11·2
Tyrosine 2 m*M*	110·0
Glycyltyrosine 2 m*M*	80·4
Phenylalanine 2 m*M*	5·7
Tyrosine 2 m*M* + phenylalanine 2 m*M*	105·0
Glycyltyrosine 2 m*M* + phenylalanine 2 m*M*	85·3
L-3.4-Dihydroxyphenylalanine 2 m*M*	11·8
Tyrosine 2 m*M* + L-3.4-dihydroxyphenylalanine 2 m*M*	9·4

acetate under the same experimental conditions, exercises no inhibitory effect on the breakdown of L-tyrosine to acetoacetate. The inhibitory effect of L-phenylalanine on tyrosine breakdown in liver *in vitro* may be due to competition with tyrosine for transport into the liver cell; but it may also be due to the formation of phenylpyruvate produced either by oxidation of L-phenylalanine in the liver or by transamination[6]. Evidence in support of the latter view is shown below.

Experiments with Radioactive L-Tyrosine and L-Phenylalanine

Confirmation of the conclusion that the presence of L-phenylalanine inhibits L-tyrosine breakdown in the liver comes from the results of experiments carried out with the radioactive amino-acids. These substances, containing carbon-14 in the α-position, give rise to radioactive (carboxyl-labelled) acetoacetate[7]; this, on treatment with aniline, liberates carbon-14 dioxide, which can be absorbed by potassium hydroxide and measured. For experiment the labelled amino-acids are placed in Warburg manometer vessels together with α-ketoglutarate and ascorbic acid in the presence of rat-liver slices. Incubation, in oxygen, is allowed to continue for 1 hr. at 37°, metabolic carbon dioxide being absorbed by potassium hydroxide in the centre well of the Warburg vessel. At the end of this incubation period the slices are removed, acid is added to the main vessel to decompose all bicarbonate and reduce spontaneous breakdown of acetoacetate, fresh potassium hydroxide is placed in the centre well, and aniline citrate is tipped into the main vessel to decompose the acetoacetate. The carbon dioxide liberated is absorbed by the potassium hydroxide. The carbonate in the latter is precipitated with barium chloride and the radioactivity of the barium carbonate is measured, corrections being made for self-absorption. Some typical results are given in Table 4. It will be observed that L-tyrosine is much more active than L-phenylalanine (for equimolar concentrations) in yielding acetoacetate. The addition of L-phenylalanine (non-radioactive or radioactive) greatly diminishes the rate of acetoacetate formation from tyrosine, the percentage inhibition, under the conditions quoted, being 60 per cent. The addition of non-radioactive tyrosine to radioactive phenylalanine also reduces acetoacetate formation from the latter molecule. This is to be expected on the basis of dilution of radioactive tyrosine, formed from the radioactive phenylalanine[8], by the addition of non-radioactive tyrosine.

The addition of sodium phenylpyruvate (2 m*M*) to the tyrosine brings about a very large inhibition of radioactive acetoacetate formation. Typical results shown in Table 4 indicate an inhibition, at the concentrations quoted, of 92 per cent. Sodium phenylacetate, however, exercises no inhibitory action on tyrosine breakdown to acetoacetate.

The inhibitory action of phenylpyruvate is seen also in the fall of respiration of liver when this ketonic acid is added to the tissue in presence of tyrosine (Table 4).

Table 4. Effects of L-Phenylalanine and of Sodium Phenylpyruvate on Radioactive Acetoacetate Formation from DL-Tyrosine (2-^{14}C) in the Presence of Rat-Liver Slices

Concentration of each amino-acid, phenylpyruvate and phenylacetate, 2 m*M*. The solutions of tyrosine (2-^{14}C) and phenylalanine (2-^{14}C) contain 10 per cent of the D-form and 90 per cent of the L-form, the final concentration of the L-form being 2 m*M*. Initial counts of radioactive amino-acids per vessel, 20,000 c./min. Present in the Warburg vessel also are potassium α-ketoglutarate 10 m*M*, sodium ascorbate 1·7 m*M* and Ringer-phosphate solution. Atmosphere in Warburg vessel, oxygen. Time of incubation, 1 hr. at 37°

	Radioactive acetoacetate formed. Counts per min. per mgm. dry weight tissue (corrected)		Q_{O_2}
Tyrosine (2-^{14}C)	169	188	12·3
Phenylalanine (2-^{14}C)	20	--	—
Tyrosine (2-^{14}C) + phenylalanine (2-^{14}C)	71	—	—
Tyrosine + phenylalanine (2-^{14}C)	10	—	—
Tyrosine (2-^{14}C) + phenylalanine	63	86	12·1
Tyrosine (2-^{14}C) + phenylpyruvate	—	16	8·9
Tyrosine (2-^{14}C) + phenylacetate	—	180	11·7

When a cell-free rat-liver extract is used instead of rat-liver slices for the oxidation of radioactive tyrosine, the addition of non-radioactive phenylalanine at an equimolar concentration exerts no inhibitory effect on the rate of acetoacetate formation. A typical result is given in Table 5.

Table 5. Effects of L-Phenylalanine and of Sodium Phenylpyruvate on Radioactive Acetoacetate Formation from DL-Tyrosine (2-^{14}C) in the Presence of Rat-Liver Extract

Concentration of each amino-acid and of phenylpyruvate, 2 m*M*. The solution of tyrosine (2-^{14}C) contains 90 per cent L-form, and 10 per cent D-form, the final concentration of L-form being 2 m*M*. Present also are potassium α-ketoglutarate 10 m*M*, sodium ascorbate 1·7 m*M*, and sodium phosphate buffer solution (0·02 *M*). Atmosphere in Warburg vessel, air. Time of incubation, 40 min. at 37°. Extract was prepared by homogenizing 5 gm. fresh rat liver in 9 ml. ice-cold 0·14 *M* potassium chloride, centrifuging the homogenate at 13,000*g* for 20 min. Supernatant was used as extract, 0·5 ml. per Warburg vessel

	Radioactive acetoacetate formed. Counts per min. per mgm. dry weight extract	
Tyrosine (2-^{14}C)	481	533
Tyrosine (2-^{14}C) + phenylalanine	517	533
Tyrosine (2-^{14}C) + phenylpyruvate	—	10

The addition, however, of sodium phenylpyruvate (2 m*M*) brings about almost complete inhibition of acetoacetate formation (Table 5).

The lack of inhibitory effect of L-phenylalanine on tyrosine breakdown in a rat-liver extract may be due to the fact that oxidation of the amino-acid does not occur in the extract (it is well known that the L-amino-acid oxidase is very unstable) and that the relevant transaminase occurs only in the insoluble-particle fraction of rat-liver homogenates[6].

These results lead to the conclusion that L-phenylalanine exercises an inhibition of tyrosine metabolism in the liver, the inhibition being effected by phenylpyruvate produced in the tissue from the phenylalanine either by oxidation or by transamination. The inhibition by phenylpyruvate is not due to isotopic dilution by hydroxyphenylpyruvate as there is no evidence that this substance is formed in rat liver[9]; nor does phenylpyruvate give rise to significant quantities of acetoacetate.

The results do not rule out the possibility that L-phenylalanine may itself exert an inhibitory effect on tyrosine breakdown; but if so, the inhibition takes place only with intact cells, for no such effect is observable in a rat-liver extract (Table 5).

Effects of L-Phenylalanine and Sodium Phenylpyruvate on Tyrosine Incorporation into Liver Proteins

The uptake of free tyrosine by rat-liver slices amounts approximately to that calculated for passive diffusion of the amino-acid into the tissue, and the uptake is not adversely affected by the presence of L-phenylalanine or phenylpyruvate (Table 6).

Incorporation of tyrosine into proteins of the liver slices is, however, definitely affected by L-phenylalanine and by phenylpyruvate, under the conditions quoted (Table 6), to about the same extent. With a concentration of 2 m*M* L-phenylalanine, an inhibition of 36 per cent of incorporation of radioactive tyrosine is obtained.

Table 6. Effects of L-Phenylalanine and Sodium Phenylpyruvate on Incorporation of Tyrosine into Proteins of Rat-Liver Slices

Conditions as in Table 4, except that initial count per vessel of radioactive L-tyrosine was 65,000 c./min.

	Incorporation of tyrosine (2-^{14}C) into liver proteins (c./min./100 mgm. tissue)	Uptake of free tyrosine (2-^{14}C) into liver slices (c./min./100 mgm. tissue)
Tyrosine (2-^{14}C)	176	1749
Tyrosine (2-^{14}C) + phenylalanine	112	1736
Tyrosine (2-^{14}C) + phenylpyruvate	96	2140

Whether the inhibitory effect of L-phenylalanine on tyrosine incorporation is due to competition for incorporation, or competition for activation preliminary to incorporation, is a matter for further investigation.

Phenylketonuria and Tyrosine Breakdown

These conclusions have a bearing on the interpretation of metabolic findings in the condition of phenylketonuria[3,4]. In this metabolic disorder, which is characterized by mental defect, the conversion of L-phenylalanine to L-tyrosine is considered to be reduced or eliminated, so that there results an increased concentration of L-phenylalanine in the blood. The amount of this amino-acid in the plasma of phenylketonuric patients varies between 15 and 60 mgm. per 100 ml.[9–11], representing an average of thirty-fold increase over the normal plasma concentration of this amino-acid. There is a similar increase in the phenylalanine concentration of the cerebrospinal fluid[10]. There is a large excretion of phenylpyruvate in these patients, but the blood concentration is not abnormally high. Phenylpyruvate is excreted in non-phenylketonurics only after ingestion of L-phenylalanine or phenylpyruvate[12].

It is evident that, if the conclusion that L-phenylalanine inhibits L-tyrosine breakdown in intact liver and L-tyrosine incorporation into proteins applies to human tissues as well as to rat liver, the relatively high concentration amounting to 2 m*M* of L-phenylalanine in the blood of phenylketonuric patients may have a considerable effect on many aspects of L-tyrosine metabolism. Whether the processes, however, that L-tyrosine undergoes in the liver, and possibly other organs, are affected by the high concentration of L-phenylalanine, will depend on whether the various enzymes involved in these processes will still work at their optimal velocities in spite of the inhibitory action of L-phenylalanine on tyrosine breakdown. Recently it has been shown[13], from measurements of oxygen consumption, that L-phenylalanine competes with L-tyrosine for mammalian tyrosinase obtained from a Harding–Passey melanoma. The competition, which amounts to an inhibition of tyrosinase activity of about 15 per cent for 1 m*M* concentrations of the amino-acids, is claimed as a possible explanation for the diminished pigmentation that seems to occur in phenylketonuric patients. This explanation would be more acceptable if it were shown that L-phenylalanine inhibits melanin formation from L-tyrosine. For, although competition with L-tyrosine for tyrosinase occurs, there may still be formed sufficient amounts of the products of tyrosine oxidation to saturate the enzymes concerned with melanin formation so that the rate of the latter process may still proceed undiminished.

It is an interesting fact[14,15] that phenylketonuric patients excrete abnormally large quantities of *p*-hydroxyphenyllactic and *p*-hydroxyphenylacetic acids. It seems possible that this may be due to transamination between L-tyrosine and abnormal quantities of phenylpyruvate formed in the tissues.

The inhibitory effects, demonstrated in this communication, of L-phenylalanine and of phenylpyruvate on tyrosine breakdown in the liver and of tyrosine incorporation into protein raise the question as to whether either or both of these substances may interfere with tyrosine conversion into products such as thyroxine, noradrenaline or adrenaline[4,16]. An interference by L-phenylalanine or by phenylpyruvate with hormone production from tyrosine may throw light on the problem of the connexion between phenylketonuria and mental defect.

It is of interest to note that, according to Bickel *et al.*[15], feeding phenylketonuric children (on a phenylalanine-restricted diet) with L-phenylalanine or phenylpyruvic acid produces a deterioration in their mental states, but no untoward effects were produced by feeding phenylacetic acid.

Results quoted in Tables 1 and 3 show the large inhibitory effects of 3.4-dihydroxyphenylalanine (2 m*M*) on the breakdown of tyrosine to acetoacetate. The mechanism of this inhibition is obscure at present, but the phenomenon serves to indicate the sensitivity of the processes of tyrosine metabolism to substances allied in chemical structure to tyrosine.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Correlation between Events in Photon Detectors

In a recent communication, Purcell[1] has discussed the experiments of Adám, Janóssy and Varga[2], Brown and Twiss[3], and Brannen and Ferguson[4] on photon correlation, and has given the results of a theoretical treatment of the phenomena. Purcell's equation 3 can be obtained from a very simple model which may help to indicate the nature of the physical processes involved.

Let us picture the radiation from each atom of an assembly as a wave-packet of duration τ_0; different atoms radiate at uncorrelated instants, the mean number of atoms radiating per second in the direction of the detector being r. Then the mean number of wave-packets falling on the detector in periods of duration T is $\bar{n}_T = r.T$, and the mean square fluctuation in this number is also $\bar{n}_T$. The probability that two wave-packets will be emitted from different atoms of the assembly at times separated by between t and $t + \delta t$ is $r.\exp(-rt).\delta t$, and the probability that the interval between consecutive emissions is less than τ_0 is therefore $1 - \exp(-r.\tau_0)$, which is approximately equal to $r.\tau_0$ as long as $r.\tau_0 \ll 1$. In this case $r.\tau_0$ is the fraction of all wave-packets emitted in conditions of partial overlap—and, within a factor of 2, the fraction of the actual time during which wave-packets are being generated in which two are being generated simultaneously.

For simplicity I assume that each separate wave-packet falling on a photo-cathode is detected, an electron being emitted at some instant within an interval of length τ_0. Were we to suppose that the wave-packets are superposed incoherently when they overlap, we should expect to observe a number $\bar{n}_T$ of photoelectrons in time T, with a mean square fluctuation $\overline{\sigma_T^2} = \bar{n}_T$.

If, on the other hand, we assume that the overlapping wave-packets are superposed coherently, 'abnormal' fluctuations in the field amplitude will result; if the overlapping wave-packets are in phase the probability of the emission of a pair of electrons within the overlap time is augmented; if they overlap in antiphase this probability is diminished. During a fraction $r.\tau_0$ of the *actual* observing period, there are these 'abnormal' fluctuations in the rate of electron emission. It is reasonable to suppose that the additional mean square fluctuation in the emission during this time, $r.\tau_0(\bar{n}_T.\tau_0)$, will be of the same order of magnitude as the mean number of electrons emitted in such a period, for the magnitude of the 'abnormal' fluctuation in field amplitude during the overlap periods is comparable with the mean field amplitude in a wave-packet. So the mean square 'abnormal' fluctuation in the electron emission will be:

$$\overline{\sigma_T'^2} = r.\tau_0\,(\bar{n}_T.\tau_0).\frac{1}{\tau_0} = \bar{n}_T\,.\,r.\tau_0$$

Hence the total mean square fluctuation in the number of photoelectrons counted in a time T is:

$$\overline{\sigma_T^2} + \overline{\sigma_T'^2} = \bar{n}_T\,(1 + r.\tau_0)$$

This is equivalent to Purcell's equation 3.

In the radio case[5], the value of $r.\tau_0$ is large—for a 100 Mc./s. radio receiver receiving a signal equal to the thermal noise in a predetector stage for which Q is 100, $r.\tau_0$ is about 10^5, and the overlap periods constitute practically 100 per cent of the total receiving time. Thus the overlapping is practically complete; it is this which makes possible phase-determinations by means of radio receivers[6].

A complete quantum mechanical account of these correlation experiments will presumably not stop short at a consideration of the photoelectric process, but will treat the mixing circuits as well. However, naïve quantum theoretical considerations do lead one to expect a coherent interference in the probability amplitude for the emission of two electrons by overlapping wave-packets, and this interference may be equivalent to the coherent superposition of the wave-packets. During the time that photon wave-packets overlap, the state of the two-photon system must be symmetrical in the two photons because of Bose statistics. This means that we cannot say which photon gives rise to which electron, and interference may arise between those parts of the probability amplitude which are associated with the two possible permutations in the couplings of emitted electrons with absorbed photons. It is presumably some such interference in the probability amplitude that explains the 'abnormal' fluctuation detected in the experiments of Brown and Twiss. On this view the effect is to be ascribed essentially to the operation of quantum statistics, as is suggested by Purcell. The result of the 'beat-frequency' experiment of Forrester, Gudmundsen and Johnson[7] can be interpreted in a similar way, as a consequence of the coherent superposition of photon wave-packets.

This does not imply, as has sometimes been suggested, that the interference between two photons may give rise to, say, four or none. The photon is not a particle, it does not survive a counting process unchanged, and it is detectable only through its interaction with matter. What does emerge from the argument above—and what can be understood in terms of this crude model and suffices to explain the experimental results—is that the interference between photons produces a distortion of the distribution in time of the events by which photons are detected.

The possible occurrence of analogous interference between electrons is mentioned by Purcell, and might be detected by allowing electron beams to strike secondary-emitting surfaces and looking for correlations between the instants of emission of the secondary electrons. Just as the photon interference has been observed[3] in 'intensity interferometers' analogous to the two types of interferometer due to Michelson, so the electron interference might be observable in an instrument analogous to Marton's recently developed electron interferometer[8]. It seems scarcely feasible to estimate the practicability of the experiment until more is known about the coherence length for electrons; the coherence length would probably have to be greater by several powers of ten than the lower limit of 5,800 wave-lengths deduced in Marton's recent work[9].

I have enjoyed stimulating discussions on this subject with my wife, and with Drs. A. R. Fraser, B. Meltzer and D. L. Pursey.

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The Question of Correlation between Photons in Coherent Beams of Light

In a recent communication, Fellgett[1] has questioned the validity of the formulæ we have quoted[2,3] for the correlation between the fluctuations in the output currents of two photoelectric detectors when they are illuminated by coherent beams of light.

These formulæ were derived by a method similar to that which we have used previously[4] for analysing the corresponding problem at radio-frequencies. The radiation field was represented by a Fourier series in which the amplitude and phase of the components were assumed to be randomly distributed, and the correlation between the intensities at the two detectors was calculated by classical electromagnetic wave theory. In the optical case, the fluctuations in the output current from each detector were then derived on the assumption that the probability of emission of a photoelectron is proportional to the intensity of the field at the respective photocathode. This analysis shows that the fluctuations in the output from a single detector exceed the simple shot noise by an amount which we have termed the "wave-interaction noise"; the shot noise components in two detectors are, of course, uncorrelated, but the wave-interaction noise is correlated when the light at the two photocathodes is mutually coherent.

Fellgett has objected to our analysis on the grounds that the "semi-classical assumptions" on which it is based do not include the totality of our knowledge about the properties of radiation, and that they are inadequate to predict fluctuations in general. In support of his arguments he directs attention to two specific points: first, the same semi-classical assumptions would not predict correctly the fluctuations in an assembly of electrons; secondly, our assumptions apparently conflict with arguments from thermodynamics.

In reply to his criticisms we must unfortunately refer to papers which have not yet been published. We have shown elsewhere[5] that the "semi-classical assumptions" outlined above are fully justified and that they yield a value for the fluctuations in the output of a single photoelectric detector, and for the correlation between two detectors, which is in precise quantitative agreement with an independent analysis[6] of the problem based on quantum statistics. Briefly, their justification rests on the fact that the relevant observables of the radiation field are not the phases and number of quanta associated with the individual Fourier components, but the relative phases and the total number of quanta associated with each component. As is well known[7], these observables can be represented by commuting operators, and thus we may treat the radiation field classically when analysing the correlation between photons. Since the same conditions do not hold for electrons, it is not to be expected that the same simple assumptions will predict the fluctuations in an assembly of electrons.

The final point raised by Fellgett is that in our analysis the ratio of the "wave" noise to the "particle noise" in the output of a photoelectric detector or, in our terminology, the ratio of the "wave-interaction" noise to the "shot" noise, is proportional to the quantum efficiency of the photocathode. In criticism of this result he quotes a formula obtained by Clark Jones[8] and by himself[9] for the fluctuations in the number of photons absorbed by a grey body in an enclosure; this formula is derived by thermodynamical arguments and predicts that the ratio of the "wave-interaction" noise to the "shot" noise should be independent of the emissivity of the body. The analysis underlying this formula is based on the assumption that the fluctuations in a thermal radiation detector are equal to the energy fluctuations in the radiation field, half being due to the absorbed and half to the emitted radiation. In the case of a photoelectric detector, where the emitted stream of radiation is absent, it is argued that the fluctuations in output should be equal to one-half the fluctuations in a grey thermal detector with an emissivity equal to the quantum efficiency of the photocathode.

Fellgett concludes from this disagreement that either there is an undetected mistake in the thermodynamical argument, or that our treatment of the photoelectric detector is wrong. Our own view is that the thermodynamical argument is unsound; our principal objection is that, although detailed balancing obviously governs the average exchange of energy between parts of a thermal system in equilibrium, it does not follow that the same holds true for the fluctuations in energy. Admittedly, the fluctuations in the energy E of a thermal detector at temperature T have a standard deviation given by the Einstein–Fowler formula,

$$\overline{\Delta E^2} = kT^2 \frac{\partial E}{\partial T}$$

but it is by no means obvious that these fluctuations can be equated with twice the fluctuations in the energy of the *incident* radiation field and, in general, we maintain that this procedure is not legitimate.

In the simple case, where the incident radiation on a photoelectric detector is effectively monochromatic and the photocathode has a quantum efficiency $\varepsilon(\nu_0)$, our expression for the wave-interaction noise in its output is less by a factor $1/\varepsilon(\nu_0)$ than that given by Fellgett and Clark Jones. It follows that, if their formula is correct, the correlation between two detectors illuminated with coherent light would be greater by a factor $1/\varepsilon(\nu_0)$ than that predicted by our analysis. We have performed two laboratory experiments[2,5] to measure this correlation and both have shown reasonable agreement with our theory. The more recent of these experiments was carried out under precisely controlled conditions and the observed correlation, using photoelectric detectors with a quantum efficiency $\varepsilon(\nu_0) = 0{\cdot}15$, was within

a few per cent of the predicted value. This result completely excludes the possibility that there is an error of the order of $1/\varepsilon(\nu_0)$ in our analysis, and proves that the formula quoted by Fellgett cannot be applied to the fluctuations in the output of a photoelectric detector.

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Relativity and Space Travel

The letters of Dr. W. Cochran and Prof. S. F. Singer[1] on this subject show that, although the issue has, I think, already been clearly outlined, much misunderstanding still persists. It is therefore worth while to point out briefly why these letters are irrelevant.

In Dr. Cochran's experiment, only the 'travelling clock' is used; the 'stationary clock' is omitted. I have already indicated[2] that on what Cochran calls 'Dingle's theory' (I have no theory; I merely accept the theory of relativity) the former will show the 'retardation', but so will the latter. To establish the so-called 'orthodox interpretation', it would be necessary to take two identical groups of particles, send one on a journey, and then show, by direct comparison at the end, that it had decayed less than the other, any direct effect of the fields applied being eliminated or allowed for.

Prof. Singer's statement that I say there is symmetry between the two observers is incorrect; I say that there is symmetry between their motions. I agree[3] that if one experiences a force which the other does not, he may show an effect of that force which the other does not, and this may indeed be as great as 1 second in 100 years. What I deny is a differential effect that is a function only of the relative velocity of the observers, which in Sir George Thomson's example is $2\frac{1}{2}$ years in 17.

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Structure of the Nitrides of Silicon and Germanium

The existence of nitrides of the compositions Si_3N_4, Si_2N_3, SiN [1] and Ge_3N_4, Ge_2N_3 [2] has been reported in the literature. The formation of two nitrides of silicon by nitriding the metal at about 1,400° C. has been reported recently[3,4]; Turkdogan and Ignatowicz state that one has the composition Si_3N_4 and that the other is a lower nitride, of composition very close to Si_3N_4.

It has been claimed[5] that Si_3N_4 and Ge_3N_4 are isomorphous and, in contradiction to the report by Juza and Hahn[6], who state that Ge_3N_4 is rhombohedral and structurally very similar to phenacite, an orthorhombic unit cell has been proposed, of dimensions $a = 13{\cdot}38$, $b = 8{\cdot}60$, $c = 7{\cdot}74$ A. for Si_3N_4 and $a = 13{\cdot}84$, $b = 9{\cdot}06$, $c = 8{\cdot}18$ A. for Ge_3N_4.

We have found the same two phases (I and II) of silicon nitride as observed by Vassiliou and Wilde[4]. These frequently occur simultaneously and it is difficult to control their relative abundance. Phase I has been obtained pure by the reaction of silicon tetrachloride and ammonia at 1,400° C., and II was found concentrated in the outer skin of a pellet of powdered silicon which had been nitrided in nitrogen at 1,400° C. for 53 hr. The corresponding phases of germanium nitride have also been formed. Heating germanium in ammonia at 750° C. gave a product which was almost entirely phase I, whereas heating germanium oxide under the same conditions gave II with traces of I. The X-ray diffraction patterns reported by Leslie *et al.*[5] and by Juza and Hahn[6] can be interpreted as originating from mixtures, in different proportions, of these two phases.

Phase II can be indexed as rhombohedral with $a = 8{\cdot}15$ A., $\alpha = 108{\cdot}0°$ for Si_3N_4 and $a = 8{\cdot}62$ A., $\alpha = 108{\cdot}0°$ for Ge_3N_4 (pseudo-hexagonal parameters $a = 13{\cdot}16$, $c = 8{\cdot}72$ A. for Si_3N_4 and $a = 13{\cdot}91$, $c = 9{\cdot}22$ for Ge_3N_4) and is structurally similar to phenacite, Be_2SiO_4, as proposed by Juza and Hahn. Phase I can be indexed as orthorhombic (smaller unit cell than that proposed by Leslie *et al.*) with $a = 3{\cdot}88$, $b = 6{\cdot}71$, $c = 5{\cdot}64$ A. for silicon nitride and $a = 4{\cdot}10$, $b = 7{\cdot}10$, $c = 5{\cdot}94$ A. for germanium nitride. The available evidence suggests, although not conclusively, that the composition of both I and II is M_3N_4. The high electrical resistivity of silicon nitride (greater than 10^{13} ohm cm.), which is considerably higher than the value (1,426 ohm cm.) quoted by Collins and Gerby[7], suggests a compound with saturated valencies.

The details of this investigation, which is being continued, will be reported elsewhere. We wish to thank Dr. T. A. Ingles for preparing the samples and Mr. F. G. Wilde for taking the diffraction photographs. We thank Dr. A. T. Green, director of the British Ceramic Research Association, for permission to publish this communication and the Ministry of Supply for financial support for this work.

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Formation of a β-Hydroxy Acid as an Intermediate in the Microbiological Conversion of Monochlorophenoxybutyric Acids to the Corresponding Substituted Acetic Acids

Wain and his colleagues[1] have clearly shown that the growth-regulating activity in plants of substituted ω-phenoxyalkylcarboxylic acids containing an uneven number of side-chain methylene groups can be explained by β-oxidation of the fatty acid side-chain within the plant to give the corresponding substituted acetic acids.

Working with the soil micro-organism *N. opaca* strain T_{16}, Webley, Duff and Farmer[2] have shown that the side-chain of ω-phenyl-substituted fatty acids also undergoes β-oxidation. It has now been demonstrated that strain T_{16} will convert 3- and 4-monochlorophenoxybutyric acids to the corresponding substituted acetic acids. Further, during these conversions an intermediate is formed which from γ-(4-chlorophenoxy)butyric acid proved to be β-hydroxy-γ-(4-chlorophenoxy)butyric acid. For this purpose the methods detailed by Webley, Duff and Farmer[2] were used. In some cases, and especially to obtain separation of the substituted butyric and acetic acids from the intermediate, it was necessary to adopt the 'multiple development' technique of paper chromatography as described by Jeanes, Wise and Dimler[3].

Experiments with strain T_{16} were set up with monochlorophenoxybutyric acids in place of the ω-phenyl substituted fatty acids used previously[2]. Other conditions remained the same. Aliquots (5 ml.) were removed aseptically, acidified, extracted with ether and the residue obtained after removal of the solvent examined by paper chromatography and infra-red analysis. Fig. 1 shows a chromatogram obtained after incubation for five days of a suspension of washed cells of strain T_{16} (4·6 mgm./ml. dry weight cells final concentration) at 25° C. in 50 ml. solution of γ-(3-chlorophenoxy)butyric acid (as sodium salt, $M/250$ concentration) under aseptic conditions. The R_F of the intermediate was 0·53 (γ-(3-chlorophenoxy)butyric acid gives 0·62 and 3-chlorophenoxyacetic acid gives 0·57). After further incubation with the addition of fresh cells as described by Webley, Duff and Farmer[4], paper chromatography of the extract showed that the spots corresponding to γ-(3-chlorophenoxy)butyric acid and the intermediate had disappeared and that only a strong spot corresponding to 3-chlorophenoxyacetic acid remained. At the end of the experiment, the product was isolated from the solution as a crystalline solid with an infra-red spectrum identical with that of an authentic sample of 3-chlorophenoxyacetic acid.

Similar results were obtained with γ-(4-chlorophenoxy)butyric acid; but in this experiment the intermediate was only slowly converted to the acetate, so that after seventeen days incubation it was possible to isolate it as a crystalline solid. The infra-red spectrum of this product (Fig. 2*a*) showed it to be principally β-hydroxy-γ-(4-chlorophenoxy)butyric acid by comparison with the spectrum of a synthetic specimen (Fig. 2*b*). An additional band in the natural product (marked by an arrow) is due to some unchanged γ-(4-chlorophenoxy)butyric acid. The intermediate was further converted to the acetate derivative by incubation with a fresh batch of cells. Finally, an experiment was set up in which the synthetic β-hydroxy compound was incubated with washed cells of T_{16}. After seven days incubation the product formed was isolated from the solution in the usual way. Infra-red examination showed it to be 4-chlorophenoxyacetic acid. The melting point (154° after three recrystallizations from benzene) was not altered on admixture with the authentic material.

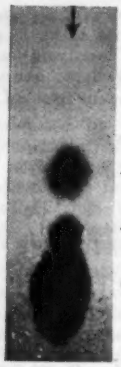

Fig. 1. *A*: γ-(3-chlorophenoxy)butyric acid; *B*: 3-chlorophenoxyacetic acid; *C*: intermediate

It seems likely that the intermediate formed from γ-(3-chlorophenoxy)butyric acid is also a β-hydroxybutyric acid. Its chromatographic behaviour resembles β-hydroxy-γ-(4-chlorophenoxy)butyric acid, which also has an R_F (0·42) lower than that of the corresponding substituted acetic acid (R_F 0·55) or substituted butyric acid (R_F 0·66).

It is established for animal tissues that one of the stages in the β-oxidation of fatty acids involves the formation of a β-hydroxy-acid derivative, although in fact such an intermediate has never been isolated[5]. The findings presented above provide direct evidence for the formation of such a compound during β-oxidation. Since no such compound was detected during the conversion of γ-(phenoxy)butyric acid to phenoxyacetic acid by the organism, it is inferred that the electronegative chlorine substituent on the ring in some way influences the β-oxidation of the fatty acid side-chain (cf. also ref. 4), presumably by weakening the attachment of the hydroxy acid to the enzyme complex. Further work is in progress on this aspect of β-oxidation and full details will be published in due course.

We are indebted to Prof. R. L. Wain, Wye College, University of London, for his encouragement during this work, and also for samples of 3- and 4-monochlorophenoxybutyric acids. We are also grateful

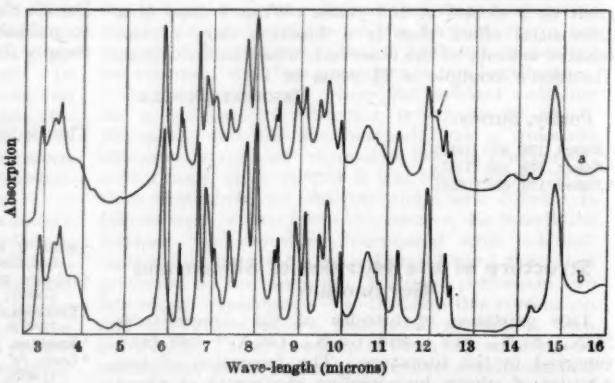

Fig. 2. Infra-red spectra of: (*a*) product from γ-(4-chlorophenoxy)butyric acid; (*b*) synthetic β-hydroxy-γ-(4-chlorophenoxy)butyric acid

to Dr. Heywood, of May and Baker, Ltd., for preparing and supplying a specimen of β-hydroxy-γ-(4-chlorophenoxy)butyric acid.

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Breakdown of Cellulose Dextrin and Gelatin in the Presence of Attapulgite

The attenuation in the breakdown of protein materials and soluble cellulose dextrin by micro-organisms with montmorillonite has been reported by Pinck *et al.*[1], Ensminger and Gieseking[2] and Lynch and Cotnoir[3]. This attenuation in the case of cellulose dextrin was attributed partially to the inactivation of the enzyme cellulase[3].

Another clay mineral, attapulgite (*p*H 8·5), intermediate in crystal structure between montmorillonite and kaolinite, has been studied using gelatin and cellulose dextrin (prepared from cellulose by degrading it with 72 per cent sulphuric acid)[4] as the substrates. Gelatin alone (100 mgm.) and gelatin plus 1 gm. of attapulgite were shaken with a phosphate buffer, *p*H 6·6, and inoculated with a soil suspension. The gelatin plus attapulgite medium evolved 4·15 m.equiv. of carbon dioxide while the gelatin alone evolved 4·03 m.equiv. of carbon dioxide. The attapulgite plus 100 mgm. of cellulose dextrin evolved 1·73 m.equiv. of carbon dioxide, while the cellulose dextrin alone evolved 2·60 m.equiv. of carbon dioxide (Table 1) after 8 days. These values have been corrected for evolution of carbon dioxide from the yeast extract control which in the presence and absence of clay gave a value of 1·82 millequivalents of carbon dioxide.

The activity of the enzyme, cellulase, was tested in an Ostwald viscometer at 25° C. using methyl cellulose (4,000 centipoise) as the substrate. 3·6 mgm. of the enzyme in 50 ml. of 0·05 *M* acetate buffer, *p*H 4·15, were shaken in the presence and absence of 100 mgm. of the clay minerals, attapulgite and montmorillonite, for 24 hr. The samples were centrifuged and 5 ml. of the supernatants were incubated for 1 hr. at 25° C. with 5 ml. of 0·5 per cent methyl cellulose. The time of efflux was then measured. It can be seen from Table 2 that, unlike the montmorillonite, the cellulase was not inactivated by the attapulgite.

Table 1. Amounts of Carbon Dioxide evolved by Soil Micro-organisms in the Presence and Absence of Attapulgite

Substrate	Amount added	Carbon dioxide (m.equiv.) corrected* for yeast extract		Protection (per cent)
		No clay	Clay	
Cellulose dextrin	(1) 100	2·66	1·80	
		2·61	1·72	
	(2) 100	2·57	1·63	
		2·51	1·79	
	(Average)	2·60	1·73	33·2
	S.D.	0·072	0·076	
Gelatin	100	4·21	4·16	
		3·85	4·14	
	(Average)	4·03	4·15	0·0

* The carbon dioxide evolved by the yeast extract control has been subtracted.

Table 2. Degradation of Methyl Cellulose (4,000 Centipoise) by Cellulase in the Presence and Absence of Clay Minerals as indicated by Efflux Time from Ostwald Viscometer

	Average time of efflux
Attapulgite	
Buffer + meth. cell.	4 min. 23 sec.
Buffer + meth. cell. + cellulase	1 min. 56 sec.
Buffer + meth. cell. + cellulase + clay	1 min. 57 sec.
Montmorillonite	
Buffer + meth. cell.	5 min. 47 sec.
Buffer + meth. cell. + cellulase	1 min. 46 sec.
Buffer + meth. cell. + cellulase + clay	2 min. 37 sec.

It is suggested, by analogy with results obtained with montmorillonite[2], that the cellulose dextrin, which exists in units of 20–30 anhydro-glucose molecules, can enter into the holes or spaces in the attapulgite lattice and is thereby protected from attack by the soil micro-organisms. The gelatin, because of its greater molecular size, is unable to do this.

Because of the prevalence of attapulgite in many soils this observation of the attenuation of breakdown of cellulose dextrin is perhaps significant in terms of soil organic matter relationships. To our knowledge, this is the first use of this soil clay mineral in this type of study.

The attapulgite, the cellulase and the methyl cellulose used in this work were commercial preparations from Ward's Natural Science Estab., Inc., the Bios and General Chemical Companies, and from Dow Chemical Co., respectively.

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Electrophoresis of Glucose Epimers

The movement of sugars in an electric field has already been used in certain analytical and preparative methods. This movement is based on the principle that borate ions form complexes with hydroxyl groups in sugars, so that these will move towards the anode in a borate buffer.

A method by which the epimerization of glucose, especially in biological material, could be estimated, would be of great interest. Therefore, electrophoresis was applied to solutions of α- and β-glucopyranose. The method used in our investigations was that of Consden and Stanier[1]. The mobilities for different sugars found by them are well reproducible.

At *p*H values slightly greater than 7·0, there is a clear difference of mobility between glucose and fructose, which is very useful in many biological, especially medical, investigations, as the R_F values in ordinary paper chromatography for these two important sugars differ very little.

A fresh solution of *d*-glucose (supposed to contain the α-form of *d*-glucopyranose), a 24-hr. solution of the same (supposed to contain an equilibrated mixture of the α- and β-forms) and *d*-glucose heated for 10 min. with pyridine (supposed to epimerize into β-glucopyranose), were subjected to electrophoresis. The 0·1 per cent solutions were made up in *M*/30 borate, at *p*H values of 9·2.

The mobilities of these epimers did not differ. Evidently, in borate buffer solutions, glucose epimers acquire the same negative charge. This method is not suitable for identifying the α- and β-form of glucopyranose.

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Quantitative Evaluation of Hæmagglutination by means of a Density Column

The ideal substance for evaluation of hæmagglutination by means of a density column must not enhance rouleaux formation or produce hæmolysis (osmotic fragility; mechanical fragility). Such a substance should not increase the sedimentation of single cells, but only of aggregates. Previous work[1] has shown that fibrinogen, certain gums, gelatin, glycogen, pectin, agar-agar, hyaluronic acid, polyacrylic acid and deoxyribonucleic acid are unsuitable. My own experience has shown that saccharose, dextrin, polyvinylpyrolidone (Antara Chemicals, Boston, U.S.A.), plasdone *C* (Antara Chemicals, Boston, U.S.A.), dextran (Grade i.v. clinical) (R. K. Laros Co., Bethlehem, U.S.A.), methylcellulose *SL* 25 (Kalle and Co., Wiesbaden-Biebrich, Germany) and cellulose-glycolate *KN* 25 (Kalle and Co., Wiesbaden-Biebrich, Germany) are also unsuitable.

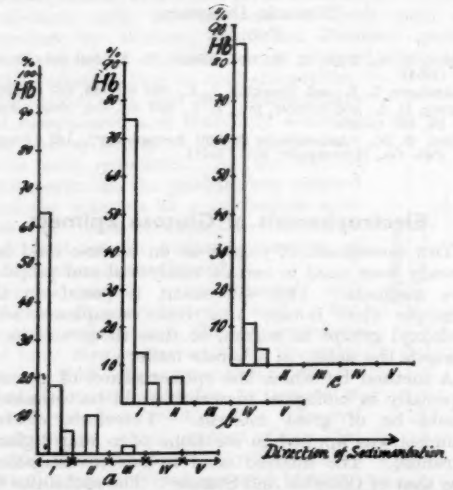

Fig. 1. Distribution of erythrocytes along the density column

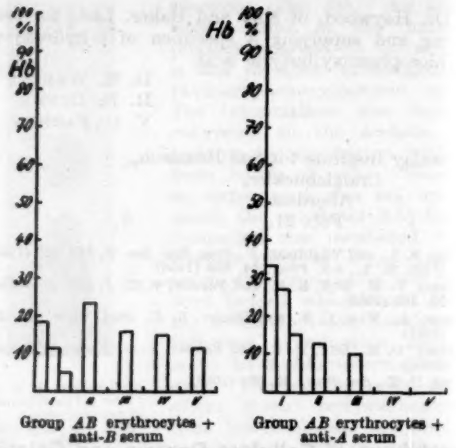

Fig. 2. Distribution of erythrocytes in the density column after agglutination

Hydrolysed dextran, Grade *L* (R. K. Laros Co. Bethlehem, U.S.A.), with an average molecular weight of 15,000–20,000, causes no rouleaux formation and it is suitable for use in a density column. Solutions of 'dextran *L*' containing 5 vol. per cent of isotonic phosphate buffer with *p*H 7·4 were found satisfactory. In order to establish the density column, 6 ml. of 'dextran *L*' solution of higher density (see Table 1) is pipetted into a burette of 25 mm. diameter. 0·9 ml. of the dextran solution of lesser density is slowly superposed upon it. A certain mixing of the medium section is achieved by 15 slow movements with a spiral-shaped glass rod[2]. Finally, 0·02 ml. of a 50 per cent suspension of washed red cells in sodium chloride are slowly added on top of the column; this suspension quickly spreads out over the whole surface, forming a film 40μ thick. After an hour the distribution of red cells along the density column is analysed. 3-ml. portions are run out of the burette and the topmost section containing most of the cells is divided up in three portions of 1 ml. each. The hæmoglobin content is measured at wave-length 580 mμ (Beckman *DU*) after freezing or hæmolysing with a fresh 5 per cent solution of saponine.

The optical density of 0·02 ml. of the 50 per cent suspension of hæmolysed red cells is taken as 100 per cent; and the reading of each section is a percentage of this. The sum of the readings of all the sections must be 100 per cent, with a tolerated deviation of ± 1 per cent. Table 1 gives some physicochemical data of the three density columns *a*, *b* and *c*.

Table 1

	a	*b*	*c*
Specific gravity	1·0439/1·0549	1·0549/1·0663	1·0663/1·0780
Viscosity index η_c	20·2/26·0	26·0/31·3	31·3/38·1
'Dextran L' (per cent)	12/15	15/18	18/21

The viscosity index η_c is a measure of the average contribution of polymer molecules at concentration *c* to the viscosity; the dimensions of η_c are cm.³/gm. The specific gravity of erythrocytes is 1·092.

In column *c* (Fig. 1), with the highest density, all red cells are still in the topmost section after 1 hr. But sedimentation of aggregates proved to be too slow, therefore column *b* was selected for further studies. The sensitivity of the density column can be varied by changing the range of the two limiting densities.

Fig. 2 shows a comparison of hæmagglutination of the blood of AB group with anti-B serum (Dade Reagents, Miami, U.S.A.) (left) and with anti-A serum (Dade Reagents, Miami, U.S.A.) (right). The former shows the stronger agglutination, with cell-aggregates down in Section IV and even section V of the column after 1 hr. Close-up views of the cell-aggregates in the different sections with phase-microscope were carried out. They should establish the interdependence between morphological and physicochemical data.

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Depolymerization of Hyaluronic Acid by X-rays

WHILE it is very well known that ionizing radiations act on many substances of biological importance, such as enzymes, simple and complex proteins and nucleic acids, there is little information about the changes caused in mucopolysaccharides. It has been reported[1] that solutions of hyaluronic acid after irradiation show a significant decrease of viscosity which is related to the intensity of irradiation. In examining the properties of irradiated conjugated proteins, such as nucleoproteins and mucoproteins, I have investigated the effects on the prosthetic groups of these molecules. The present communication deals with the action of X-rays on hyaluronic acid.

The acid mucopolysaccharide was isolated from umbilical cord and purified to provide preparations homogeneous in the electrophoresis and ultracentrifuge. Irradiations were carried out with soft X-rays in a 'Dermopan' apparatus (beryllium window; 45 kV.; 25 m.amp., at distance of 5 mm. from the window).

After irradiation of a 1 per cent solution of hyaluronic acid, a slight opalescence was observed and an immediate decrease of the viscosity to values very close to that reported by Schoemberd *et al.*[1], when calculated for the same dose of X-rays. Fig. 1 shows the electrophoretic pattern of irradiated hyaluronic acid; it seems clear that, after irradiation, the single boundary is split into several components migrating with lower velocity. The mobility observations are summarized in Table 1.

In the ultracentrifuge the sharp and symmetrical boundary of hyaluronic acid after irradiation becomes somewhat broader and the sedimentation constant is lowered. This behaviour is very similar to that of hyaluronic acid which has been depolymerized by hyaluronidase. The sedimentation results are shown in Fig. 2.

Assuming the same diffusion constant for irradiated and unirradiated hyaluronic acid—unfortunately it is not possible to determine the exact diffusion constant after irradiation, because of the splitting of irradiated hyaluronic acid into several components—the molecular weight of hyaluronic acid appears to be lower after irradiations.

Table 1. MOBILITY DATA, AT pH 7, OF UNIRRADIATED AND IRRADIATED (200 × 10³ R.) HYALURONIC ACID

	$U \times 10^{-5}$ cm.² sec.⁻¹ volt⁻¹
Unirradiated hyaluronic acid	10·5
Irradiated hyaluronic acid	
1st component	7·6
2nd component	4·2
3rd component	1·8

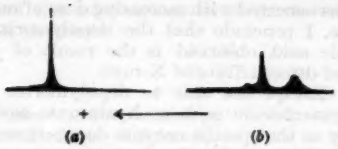

Fig. 1. Electrophoretic pattern of (a) unirradiated, and (b) irradiated (200 × 10³ r.) hyaluronic acid. Phosphate buffer, pH 7, μ 0·1. Exposures taken at same time intervals

It seems, therefore, that ionizing radiations are able to determine a kind of depolymerization of hyaluronic acid; this has been confirmed with the occurrence of free glucosamine in solutions of irradiated hyaluronic acid. Further, quantitative estimation[2] has shown that the amount of glucosamine liberated from irradiated hyaluronic acid is proportional to the X-ray dose (see Fig. 3).

To ascertain whether the changes observed in irradiated hyaluronic acid are due to the indirect or direct action of X-rays, some experiments have been carried out with dry hyaluronic acid, when similar

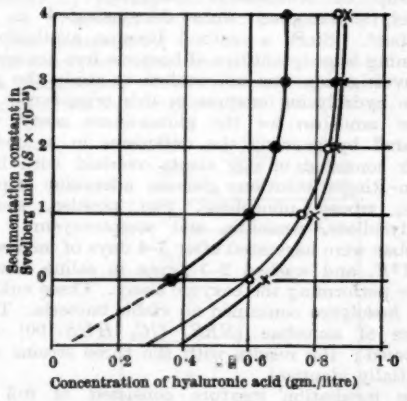

Fig. 2. Sedimentation constants of unirradiated (●——●), irradiated (200 × 10³ r.) hyaluronic acid (○——○) and hyaluronic acid treated with hyaluronidase (×——×)

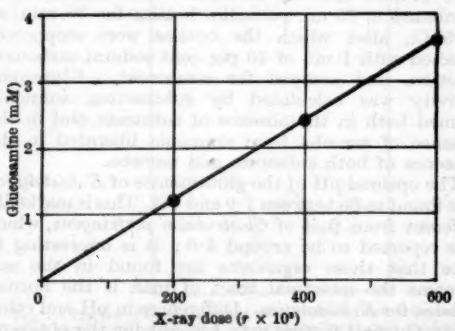

Fig. 3. Quantitative estimation of glucosamine liberated from irradiated hyaluronic acid

alterations occurred with increasing dose of radiations. Therefore, I conclude that the depolymerization of hyaluronic acid observed is the result of both indirect and direct effects of X-rays.

Hence X-rays are able to depolymerize an acid mucopolysaccharide such as hyaluronic acid in the same way as the specific enzyme does; it seems that ionizing radiations, like hyaluronidase, act on hyaluronic acid by opening the N-acetylglucosaminic bond.

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Occurrence of Glutaminase in *Endamoeba histolytica*

The existence of glutaminase in bacteria has been demonstrated[1-3]. However, to our knowledge no work has been done on other micro-organisms such as Protozoa. Little is known on the enzymatic make-up of *Endamoeba histolytica*[4]. Recently, proteolytic enzymes were demonstrated in the amoebae[5]. Since a method became available for obtaining large quantities of bacteria-free amoebae[6,7] an investigation was undertaken to study the glutamine hydrolysing enzyme in this organism.

The amoebae for the glutaminase assay were prepared by growing the organisms in a medium which consisted of egg slants overlaid with horse serum–Ringer solution, glucose, adenosine triphosphate, ribose-5-phosphate, rice powder, sodium thioglycollate, penicillin and streptomycin. The amoebae were harvested after 3–4 days of incubation at 37° C. and washed 2–3 times in saline solution before performing the enzyme assay. These cultures of *E. histolytica* contained no viable bacteria. Three strains of amoebae (*NRS*, *UC*, *HUS*-100) were employed; the results with the three strains were essentially identical.

The incubation mixture consisted of 0·3 ml. amoeba suspension (approximately 1,000,000 amoebae per ml.), 0·5 ml. 0·1 *M* veronal–hydrochloric acid buffer, 0·1 ml. 0·1 *M* *l*-glutamine, 0·1 ml. 0·9 per cent sodium chloride solution. The mixture was incubated in 25 ml. penicillin bottles for 30 min. at 37·5° C., after which the bottles were stoppered, injected with 1 ml. of 20 per cent sodium carbonate solution, and assayed for ammonia[8]. Glutamine activity was calculated by subtracting ammonia formed both in the absence of substrate and in the absence of amoeba from ammonia liberated in the presence of both substrate and amoeba.

The optimal *p*H of the glutaminase of *E. histolytica* was found to be between 7·0 and 7·5. This is markedly different from that of *Clostridium perfringens*, which was reported to be around 5·0; it is interesting to note that these organisms are found in the soil whereas the intestinal tract of man is the normal habitat for *E. histolytica*. Differences in *p*H and other environmental factors may account for the optimum *p*H of the glutaminase of *E. histolytica*. With regard to activators of glutaminase, the amoebic enzyme is more like mammalian glutaminase than the bacterial enzyme. The former is activated by phosphate and the latter by monovalent anions. Only phosphate activated the amoebic glutaminase; sodium chloride did not activate this enzyme in the amoebae.

Thus the occurrence of a phosphate-activated glutaminase in *E. histolytica* has been established.

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Occurrence of Flavokinase Activity in Plants

Riboflavin functions biologically as either flavin mononucleotide or flavin-adenine-dinucleotide, which constitute the prosthetic group of a variety of enzymes[1]. A study of pathways through which these nucleotides themselves are synthesized from the free vitamin would be valuable. The only reports in the literature regarding the enzymatic synthesis of flavin mononucleotide pertain to the study of the enzyme from baker's yeast[2] and a riboflavin-excreting mutant yeast *BY2*[3]. On the basis of the specificity and stoichiometry of the reaction, the enzyme was designated 'flavokinase'. In this communication, the occurrence of the enzyme in plants is reported for the first time.

For the preparation of enzyme extracts, 5 gm. of the acetone-dried powders were ground with equal weights of 'Pyrex' glass powder and 10–15 ml. water, and extracted in the cold (0–5°) for 16–18 hr. The supernatant of this extract was dialysed at 0–5° for 4 hr. The precipitate resulting after dialysis was centrifuged off and the supernatant was used as the enzyme. The identity of flavin mononucleotide was established as follows. A 40 ml. reaction mixture consisting of 2 ml. adenosine triphosphate solution (obtained by converting 40 mgm. of barium adenosine triphosphate[4] to the sodium salt), 2 ml. sodium fluoride solution (1×10^{-1} *M*), 2 ml. of manganese sulphate solution ($3{\cdot}0 \times 10^{-4}$ *M*), 4 ml. of riboflavin solution ($1{\cdot}0 \times 10^{-4}$ *M*), 14 ml. of veronal–hydrochloric acid buffer (0·1 *M*) *p*H 8·4 and 16 ml. of enzyme preparation (from *Phaseolus radiatus*) was incubated at 37° for 18 hr. The reaction was stopped by adding 16 ml. of 17·5 per cent trichloracetic acid and heating at 80–85° for 5 min. The supernatant was subjected to preparative circular paper chromatography[5]. The eluate of the band corresponding to flavin mononucleotide showed absorption maxima in the region 264–266 mμ. It was chromatographically identical with an authentic sample of flavin mononucleotide. On chemical, as well as enzymatic, hydrolysis of the product, liberation of phosphate occurred, and riboflavin was the only flavin formed after such

Table 1

	Plant source*	Flavokinase activity† (mμ *M* flavin mononucleotide synthesized at 37° and *p*H 8·4 per 2 ml. reaction mixture per 5 hr.)
1	*Cicer arietinum* (Bengal gram)	99·7
2	*Ricinus communis* (castor seed)	85·9
3	*Brassica campestris* (mustard)	82·8
4	*Phaseolus mungo* (black gram)	76·7
5	*Phaseolus radiatus* (green gram)	79·7
6	*Dolichos biflorus* (horse gram)	99·7
7	*Dolichos lablab* (field bean)	148·8
8	*Canavalia gladiata* (sword bean)	118·1
9	*Pisum sativum* (pea)	99·7
10	*Sesamum indicum* (sesame)	99·7
11	*Cajanus indicus* (red gram)	99·7
12	*Solanum tuberosum* (potato)	73·6
13	*Ipomoea batatas* (sweet potato)	70·0

* Enzyme preparation from sources 1–11 were obtained by using resting seeds.

† 2 ml. reaction mixtures contained riboflavin ($1·0 \times 10^{-4}$ *M*), adenosine triphosphate (crystalline sodium, $1·0 \times 10^{-3}$ *M*), sodium fluoride ($1·0 \times 10^{-1}$ *M*), magnesium sulphate ($3·0 \times 10^{-4}$ *M*), 0·7 ml. of 0·1 *M* veronal–hydrochloric acid buffer *p*H 8·4 and 0·8 ml. enzyme preparation.

degradation. Flavin mononucleotide was estimated by the method of Giri and Krishnaswamy[3], by subjecting the supernatants to chromatography, identifying the flavins under ultra-violet light, eluting the flavins in water and measuring their fluorescence in a Klett fluorimeter. Appropriate controls which included sets in which adenosine triphosphate was omitted were also carried out. Flavokinase activity was found to be optimum in the *p*H-range 8·0–8·4 and at 37°. The flavokinase activities of the plant materials investigated are presented in Table 1.

In Fig. 1 the increasing synthesis of flavine mononucleotide in reaction mixtures containing riboflavin, adenosine triphosphate and an enzyme preparation from *Phaseolus radiatus*, with increase in incubation period, can be observed. The occurrence of this enzymatic process in plants points to the similarity of pathways through which trace substances like flavin mononucleotide are synthesized in yeasts and plants. Further work on purification, properties and kinetics of this enzyme are in progress and will be published elsewhere.

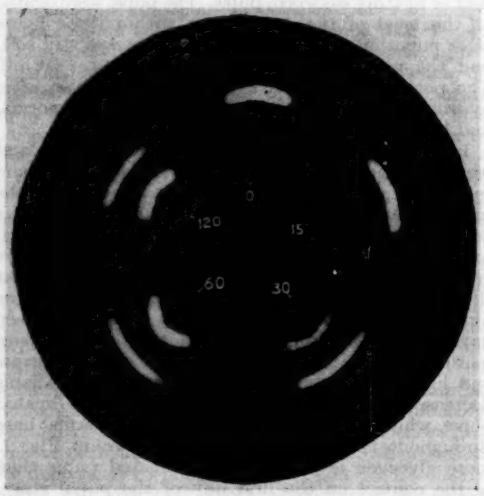

Fig. 1. Chromatogram showing the synthesis of flavin mononucleotide (lower band) from riboflavin and adenosine triphosphate by extracts of *Phaseolus radiatus* at different intervals of incubation (in minutes). Photograph was taken in ultra-violet light using a filter of saturated sodium nitrite solution

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Substance appearing in Steroid-containing Plasma Extracts after Ingestion of Tea or Coffee

In the course of paper chromatography of chloroform extracts of human plasma several ultra-violet absorbing spots, in addition to that produced by cortisol, have frequently been encountered, both by ourselves and by others[1]. Attention was directed to one of these when it was found that in the fasting state it was no longer detectable. (In our experiments the plasma was extracted three times with 1·5–3 volumes of chloroform. A clean extract was obtained by mixing the plasma with one-fortieth volume *N* sodium hydroxide immediately prior to the first extraction[2].)

The absorption spectrum of the chloroform eluate from this region of the chromatogram showed a maximum in the neighbourhood of 275 mμ, which

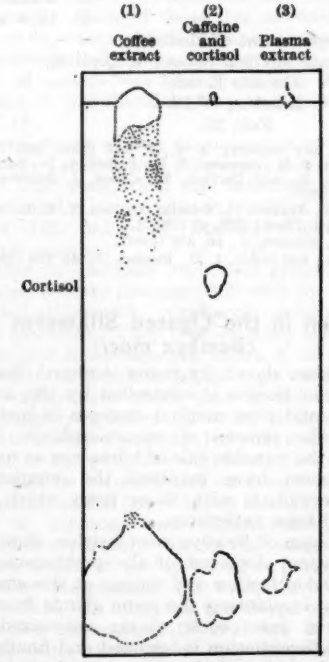

Fig. 1. Tracing of spots absorbing ultra-violet light on a chromatogram run for 6½ hr. at 28° C. in toluene–75 per cent methanol. (1) Chloroform extract of 0·5 ml. coffee percolate, (2) caffeine and cortisol standards, and (3) chloroform extract of 20 ml. plasma, obtained after ingestion of a cup of coffee

was unchanged when the spectrum was determined in alkaline solution (0·46 *N* potassium *tert.*-butoxide in *tert.*-butanol) instead of in chloroform. The position of the maximum was also unchanged whether the chloroform solution was (*a*) washed with water, *N* sodium hydroxide or *N* hydrochloric acid, or (*b*) taken to dryness and the residue heated in a boiling water-bath with *N* hydrochloric acid for 1½ hr., then concentrated and redissolved in chloroform. After treatment (*b*) the chromatographic behaviour of the material was unaltered. These chemical properties, together with the finding (see Fig. 1) that the ultra-violet absorbing spot appeared on chromatograms of plasma extracts after the ingestion of a cup of coffee, suggested that the unknown material might be a dietary purine. In a normal subject, from whom 20 ml. blood was taken 3, 6 and 9 hr. after the ingestion of a cup of coffee, the ultra-violet absorbing spot on the chromatogram was most obvious at 3 hr. R_F values in three solvent systems (0·5–0·6 in toluene–75 per cent methanol[3], 0·66 in butanol–water[4], and 0·63 in amyl alcohol–water[4]) were the same as that of a caffeine standard run at the same time. Chromatography in toluene–75 per cent methanol of a mixture of caffeine with a plasma extract containing the unknown constituent gave only a single spot. An ultra-violet absorbing spot with the same R_F value was also found on chromatograms of plasma extracts after ingestion of a cup of tea, and on chromatograms of chloroform extracts of a coffee percolate. It seems, therefore, that the unknown compound is either caffeine or a closely related substance.

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Glycogen in the Ligated Silkworm Pupa (*Bombyx mori*)

It has been shown by many workers[1] that metamorphosis in insects is controlled by the action of hormones, and that marked changes in metabolism occur in the process of metamorphosis. Recent studies on the possible role of hormones as regulators of metabolism have involved the comparison of normal individuals with those from which specific organs had been extirpated.

Young pupæ of *Bombyx mori* (within about 15 hr. after pupation) deprived of the prothoracic glands cannot develop further and remain at this stage until death. By implanting the same glands from intact donor pupæ into such young ectomized pupæ, imaginal differentiation is resumed and finally adults emerge[2]. In spite of the fact that the role of the prothoracic gland hormone in the imaginal differentiation is thus evident, we still have no idea of the metabolic changes induced by this hormone at the early pupal stage. One of us (T. I.) has shown[3] in silkworm pupæ ligated at the level of thorax for the purpose of eliminating the effects of the prothoracic gland hormone (1) that discontinuous output of carbon dioxide occurs, (2) that the rate of the respiration and the proportion of cyanide-insensitive respiration are decreased and remain at low levels without showing any increase until death, and (3) that the activities of cytochrome *c* oxidase, succinoxidase and succinic dehydrogenase are decreased. From these observations it was concluded that the ligated pupæ seem to be in the same physiological condition as those of the diapausing pupæ of other kinds of insects.

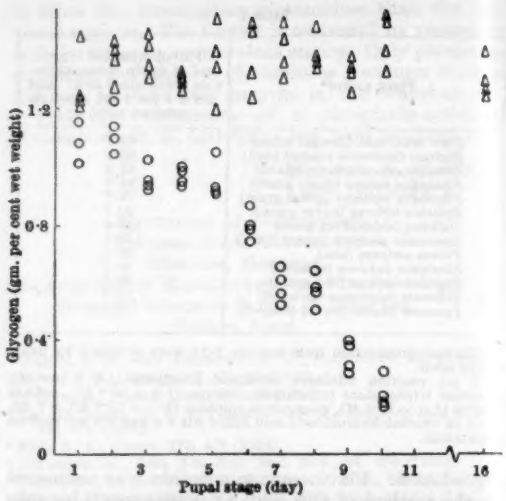

Fig. 1. Variation of glycogen content in normal and ligated silkworm pupæ (male). ○, Normal pupa; △, ligated pupa. On the first day of the pupal stage, the pupæ were ligated and the determination was done shortly after ligation. On the eleventh day adults emerged in the control

We have now examined the effect on glycogen content of ligating silkworm pupæ. The pupæ were ligated at the level of the metathorax within three hours after pupation, while the pupal cuticle was still soft, and the part anterior to the ligation was cut off. The posterior part was analysed for glycogen after hydrolysis to free glucose[4]. The results for normal and ligated pupæ are shown in Fig. 1.

In normal pupæ the glycogen content per gm. wet weight is decreased during pupal development and reaches a value of approximately one-fifth of the initial value at the end of the pupal stage. This confirms results already published by several authors[4] and suggests that glycogen is consumed as one of the energy sources. In the ligated pupæ, however, almost the same level of glycogen is maintained during the nine days following the operation, and even fifteen days after ligation. Since there is no marked difference in the decrease in the body-weight between normal and ligated pupæ, it is evident that no appreciable decrease in glycogen content occurs in the ligated pupæ, while it decreases markedly in the normal ones throughout the pupal stage. As shown in Fig. 1, more glycogen is present in the ligated pupæ than in the control on the first day of the pupal stage. This suggests that glycogen is distributed more densely in the posterior half of the pupal body than the anterior half, because the ligated pupa consists of posterior thorax and abdomen. Since the marked

decrease in glycogen is one of the metabolic features associated with metamorphosis, the maintenance of glycogen-level in the ligated pupæ is considered to be due to the absence of the prothoracic gland hormone. In other words, glycogen is decreased in the presence of a regulator, in this case the hormone secreted from the prothoracic gland at the early pupal stage. It is more reasonable to consider that the glycogen is not degraded in the ligated pupa than to postulate that the rate of synthesis of glycogen is of the same order of magnitude as glycogenolysis. The most probable mechanism is that a series of glycolytic enzymes are activated by the prothoracic gland hormone and present at the time of histolysis.

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Reversal by Diethyl-Stilbœstrol of the Depressant Effect of Cortisone on the Phagocytic Activity of the Reticulo-endothelial System

MUCH has already been published showing that cortisone depresses the reaction of the body to common bacterial infections in both animals and man[1]. In the human subject there is evidence that it may induce activity in a quiescent tuberculous lesion[2], while sudden death from acute fulminating pneumonia has been recorded in cases of rheumatoid arthritis under treatment with cortisone. It is, however, now accepted that severe intercurrent infection tends to occur only when large doses are given, and Wayne[3] is of the opinion that the critical dose of cortisone in the human subject is about 75 mgm. per day, since adverse side-effects commonly develop in patients receiving more than 100 mgm. daily.

The mechanism by which cortisone depresses the body defences has been shown by Nicol, Snell and Bilbey[4] to be due to depression of the phagocytic activity of the reticulo-endothelial system, the total and differential white cell counts in the blood and the gamma globulin level in the serum; and its beneficial use in disease is probably due to a similar mechanism whereby it depresses the inflammatory reaction of the patient and thus holds in check the cycle of pathological changes. They also showed that the depression of phagocytic function occurs chiefly during the first two weeks of cortisone treatment and that during the third and fourth weeks the phagocytic activity returns to normal, although the blood picture and the concentration of gamma globulin in the serum remain altered. These findings suggested that it is during the early stages of treatment with large daily doses of cortisone that intercurrent infection is most likely to develop. In contrast, the œstrogens have been shown by Nicol, Helmy and Abou-Zikry[5] to stimulate the phagocytic activity of the reticulo-endothelial system, the strongest stimulant being diethyl-stilbœstrol.

The present research was designed to ascertain whether or not the depressant action of cortisone on the phagocytic activity of the reticulo-endothelial system could be reversed by diethyl-stilbœstrol. For these investigations, male white mice (T.O.Swiss strain) of 20–30 gm. body-weight were used. The phagocytic activity of the reticulo-endothelial system was studied as follows. Each animal received one intravenous injection of carbon of particle size 250 A., the dose of the carbon being calculated on the basis of 16 mgm. per 100 gm. body-weight. The rate of disappearance of the carbon from the circulating blood, which has been found to be a measure of phagocytic activity, was then recorded by an absorptiometer. The logarithmic values of the absorptiometer readings give an exponential curve, the tangent of which has been taken to indicate the phagocytic activity or phagocytic index[6], which is denoted in the present communication by the symbol K.

Eighty control animals used in this and other experiments were given carbon only, and showed an average phagocytic index or K value of 26.

Five animals each received 0·5 mgm. of cortisone acetate (Roussel) daily subcutaneously for one week. The administration of cortisone was then stopped, and each animal was given one injection of carbon and the phagocytic index K recorded as described above. The average K value was now found to be reduced to 7. Each of these five animals then received one injection of 0·5 mgm. diethyl-stilbœstrol subcutaneously daily for a further week. A second injection of carbon was then given and the phagocytic index K was found to be raised to an average value of 46.

A second group of five animals each received 0·5 mgm. diethyl-stilbœstrol (Organon) subcutaneously daily for one week, then one injection of carbon. These recorded a phagocytic index K of an average value of 105, indicating marked stimulation of phagocytic activity.

A further five animals were each given 0·5 mgm. of cortisone acetate (Roussel) followed by 0·5 mgm. of diethyl-stilbœstrol (Organon) subcutaneously daily for one week. They then received one injection of carbon and the phagocytic index K of the group was found to be raised to an average value of 68.

These experiments show that in the mouse the normal phagocytic index ($K = 26$) is depressed by cortisone to the low figure of 7, but that if the cortisone treatment is stopped, the depressant action of the cortisone can be reversed and converted into one of moderate stimulation ($K = 46$) by diethyl-stilbœstrol. Further, if cortisone and diethyl-stilbœstrol are administered separately but at the same time, the depressant action of the cortisone is prevented and considerable stimulation ($K = 68$) of phagocytic activity occurs. In addition, the above results have been verified microscopically and are in complete agreement with those previously recorded[5,7] using the trypan blue technique.

Clinically these results suggest that when an intercurrent infection develops during cortisone therapy, not only should the cortisone be stopped and prob-

ably a suitable antibiotic given, but also the defence of the patient should be stimulated by diethylstilboestrol. They also indicate that, in cases in which the cortisone cannot be withdrawn, diethylstilboestrol can be given at the same time to increase the general defence against infection. At least clinical trials seem to be indicated along these lines.

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Some Indole Constituents of Cabbage

3-Indolylacetic acid has long been recognized as a naturally occurring plant auxin, but the problems of its origin, mode of action and metabolism are not yet fully elucidated. In particular, several pathways for the *in vitro* degradation of 3-indolylacetic acid by oxidase systems have been postulated, but no unequivocal evidence for the chemical nature of the products from such reactions has yet been presented.

With the isolation of 3-indolylacetonitrile from cabbage and the realization of its growth-promoting properties[1], it has been of interest to examine the metabolism of this compound in the cabbage plant. Failing attempts to demonstrate an indolylacetonitrile–oxidase activity in purified cell-free extracts of cabbage material, it has been possible to obtain some insight into the problem by investigating the occurrence of other indole derivatives in the plant. We wish to report the isolation from cell-free *aqueous* extracts of cabbage, by ether extraction and the use of adsorption and partition chromatographic techniques, of indole-3-aldehyde and indole-3-carboxylic acid. The compounds were identified by melting point and mixed melting point, analysis, ultraviolet and infra-red spectra, by the preparation of derivatives, and by chromatographic comparison with authentic specimens of the two substances. Indole-3-aldehyde was isolated initially from maturing plants (var. January King), the yield being 6·5 mgm. from 1·9 kgm. of plant material; the presence of indole-3-carboxylic acid was suggested by paper chromatography—a spot with R_F 0·44 (*iso*propanol/0·15 *N* ammonia) giving an orange colour with ferric chloride spray reagent. Following this work, fully grown plants (var. Early Offenham, 9·1 kgm.) yielded the aldehyde (67 mgm.) and the acid (3·5 mgm.). 3-Indolylacetonitrile was present in trace amounts in both cases, but no indication of the presence of 3-indolylacetic acid was obtained.

Indole-3-aldehyde has previously been claimed, on the evidence of paper chromatography, to be present in cabbage and other crucifers[2] and it has been suggested as a product of the enzymatic oxidation of 3-indolylacetic acid[3]. Indole-3-carboxylic acid has been shown to arise when 3-indolylacetonitrile is applied to plant tissue, the reaction being considered an example of the general process of α-oxidation of nitriles, and in addition the compound has been detected in peas[4]. The present work confirms these reports of the occurrence of the compounds, and suggests that side-chain degradation, as distinct from ring fission, is one form of auxin inactivation operating within the cell.

Small amounts of a third 3-substituted indole were also isolated in both cases, and the chemistry of this new compound is being further investigated.

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Effect of Low Temperature on the Breeding of Marine Animals

The work of Appellöf[1], Runnström[2] and Orton[3] directed attention to the importance of sea temperature in determining the geographical limits within which a marine animal could breed. It is now well known that the breeding season may vary over the different parts of the range, according to the annual variation in temperature at different latitudes. This effect is particularly evident in species which are adapted to warmer seas; their breeding season in more temperate waters is increasingly restricted to the warmest months. Recently, Loosanoff and Davis[4] have demonstrated experimentally that certain of these organisms, notably *Venus mercenaria*, can be brought into the breeding condition in winter by gradually raising the temperature of the water in which they are kept and providing them with suitable food.

Arctic forms living in temperate latitudes generally produce fertilized eggs in winter or in early spring, which suggests an inability to breed at higher temperatures. However, there is little evidence that in arctic waters they spawn over a more extended period, or that the season of egg production is displaced into the summer months. On the contrary, those groups with predominantly planktotrophic larvæ, such as fish and cirripedes, which breed in winter or spring in temperate latitudes breed also during the same period in the arctic[5–7]. This may have an advantage in giving the larvæ an early start in a short growing season[6].

So far, I do not think that the direct effect of low temperature in promoting the breeding of cold-water forms has been explored by experiments analogous to those of Loosanoff. The results of work recently carried out in this laboratory may therefore be of general interest as well as of practical value.

Two species of arctic barnacles, *Balanus balanoides* L. and *Balanus balanus* (L) (= *B. porcatus* Da Costa), which normally become fertilized once a year in November and February respectively[6], have been kept in the laboratory at different temperatures for long periods. Those maintained at temperatures

fluctuating between 14° and 18° C. did not become fertilized or show any copulatory activity at the normal breeding season. The only exceptions were barnacles brought into the laboratory a few days before breeding activity began in their natural habitat. These individuals produced normally fertilized eggs at temperatures greatly exceeding those prevailing in the sea at the time. *B. balanoides*, for example, bred at a temperature of 17° C. and *B. balanus* at a temperature at least as high as 11° C. It is evident, however, that a prolonged period of high temperature prevents the animals from reaching the breeding condition.

Specimens of *B. balanoides* were collected in summer and kept in tanks at temperatures ranging between 3° and 10° C., aeration being provided by mechanical stirring. Breeding commenced after one or two months, the interval depending on the temperature and the previous history of the barnacles. These individuals became fertilized and eventually produced viable larvæ. Similar results were obtained with *B. balanus*. Thus by maintaining individuals at a low or high temperature it is possible to cause breeding to take place at times of the year other than the normal breeding season. The procedure is extremely simple since, provided eggs are developing in the ovary, there is no need to feed the barnacles while they are being brought to maturity at low temperature. Indeed the evidence, though not yet conclusive, suggests that starvation accelerates maturation.

Further experiments are being undertaken to establish more precisely the relationship between temperature and breeding. It seems probable that the southern limit of *Balanus balanoides*, which approximates to the winter isotherm[2] for 45° F., and possibly that of *B. balanus* also, is related to the need for a sufficiently long period of low temperatures to allow breeding to start, or to start sufficiently early.

There is also a practical application of these experiments to anti-fouling research. It is often useful when considering materials which may form the toxic basis of an anti-fouling paint to carry out screening tests against barnacle larvæ using solutions of the test substance in sea-water. These tests are simple and rapid, and they avoid wasted effort in formulating a paint from substances which may be unpromising from the outset. Most barnacles, however, breed only for part of the year, the larvæ of *Elminius modestus* alone of British species being available for such tests throughout the year in certain districts[9]. By the procedure described above, it should now be possible to have available throughout the year a supply of larvæ of *Balanus balanus* and *B. balanoides*, which are larger and therefore more convenient to use than those of other species.

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A New Technique for Climatological, Nutritional and Energy Metabolism Studies with Ruminants

Projects dealing with the relationship between animals and their climatic environments have been growing in frequency for some time past. In particular, climatological chambers have been established wherein domestic animals can be subjected to controlled variations in temperature, humidity, rainfall, wind, etc. Nutritional and energy metabolism studies are also receiving concentrated attention with the building of room-type calorimeters going on at several centres. At this laboratory, however, during the examination of certain physiological processes in sheep, a new technique has been devised which overcomes to a certain degree the need for such costly installations before calorimetric work can proceed.

This technique is basically a method of indirect calorimetry, which overcomes the disadvantages inherent in procedures adopted by other workers in this field who have used face masks on ruminants. The use of a face mask on the ruminant has always presented peculiar problems on account of the large amounts of fermentation gases, mainly carbon dioxide and methane, which are continually generated in the rumen and periodically voided by eructation. Eructated and exhaled carbon dioxide is removed easily from a closed circuit by an agent such as soda lime. However, methane production varies within wide limits and it is not easy to remove it from a closed circuit. Consequently, many workers have been forced to adopt correction factors to readings taken when its production has fallen to a reasonable level after a period of fasting.

Briefly, the new technique involves fitting the experimental animals surgically with tracheotomy tubes (modified Fields pattern; 11 mm. lumen). The tubes are worn permanently and kept plugged except when recordings are to be made. The solid plug is then replaced by a hollow cone attached to the spirometer—in this case a McKesson basal metabolic rate machine designed for human usage which automatically records oxygen consumption over a time period. The hollow cone is fitted with a 2 mm. diameter by-pass tube which, extending some 6 cm. beyond the cone itself, is bent in an arc corresponding to the curvature of the upper arm of the tracheotomy tube so that the free end is located within the lumen of the upper trachea when the cone is fitted over a smaller cone attached to the outer plate of the tracheotomy tube. A deflated rubber balloon is securely attached to the free end of the by-pass tube and is gently inflated and clamped off after insertion of the tube. By this device the upper trachea is completely occluded and the true pulmonary gaseous exchanges recorded on the spirometer.

To ensure a perfectly air-tight joint between the tracheotomy tube and the neck when recordings are taken, a sponge-rubber pad and an inflatable cuff are sealed into position between the base plate of the tracheotomy tube and the skin with plastic putty. A cannula is being designed to obviate the need for any external seal.

The insertion of the balloon is not resented in any way by the sheep. Its placing takes only a few seconds and usually causes only one or two slight coughs due to reflex irritation of the tracheal mucosa. To reduce irritation to a minimum, the deflated balloon

is lightly smeared with a non-oily analgesic jelly prior to insertion.

A programme touching on several aspects of ruminant physiology and nutrition has been built up. The detailed results of these researches will be published from time to time over the next two years.

Acknowledgment is made of the financial support of the Research Committee of the University of New Zealand and of the co-operation of Mr. W. M. Webster, head of the Veterinary Department, Massey Agricultural College, who was responsible for many helpful suggestions and the surgery which he will report on elsewhere.

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Bovine Leptospirosis in Kenya

In Africa evidence for the existence of leptospirosis in ruminants has been found in the Belgian Congo[1], Algeria[2] and Tunisia[3]. We now record disease in cattle, sheep and goats in Kenya caused by leptospiræ.

During May 1956, deaths occurred in all three species on ten farms on the Uaso Nyiro River in the Nanyuki District. Jaundice, red discoloration of milk, photosensitization-like lesions of unpigmented areas of skin, particularly that covering the udder and teats, and darkening of urine were the main symptoms noted in the acute syndrome in cattle. Subacute cases were also seen, with death after a long period of ill-defined sickness with loss of condition. Native and cross-bred sheep and native goats were also affected, but merino sheep on adjoining parts of the farms did not become infected. Disease in the smaller ruminants was usually hyperacute. At post-mortem the main findings were nephritis with inconstant jaundice.

The first laboratory confirmation was in necropsy material from a cow during the natural outbreak, by the observation of leptospiræ in the formalinized urine sample using dark-ground microscopy and of masses of leptospiræ within kidney tubules in histological sections stained by the Warthin–Starry method. Similar findings have since been made in specimens from goats and further cattle. A series of animals was inoculated with fresh kidney material from a clinical case in a goat. The acute disease was reproduced in a pregnant ewe and chronic infections established in sheep, goats, yearling steers and pigs. In pigs, massive urinary excretion of leptospiræ has occurred without clinically detectable illness.

The guinea pig has proved to be relatively insusceptible to the leptospiræ concerned, but infections with death at 9–11 days after intraperitoneal inoculation have been regularly reproduced in golden hamsters.

Leptospiræ have been isolated in pure culture in Fletcher's and Korthof's media from hamster tissues and blood, during passage in this species. Isolations have also been made, seven days after inoculation, from the heart blood of chicks given infective material by the intraperitoneal route at two days of age.

Chronic kidney lesions have been found at the abattoir in apparently healthy steers from affected farms. Histologically, the lesions resemble those described by Hadlow and Stoenner[4] in chronic *L. pomona* infection. Leptospiræ have been isolated from some of these and seen in others by dark-ground microscopy.

The species of leptospira involved is being determined.

It is hoped to publish this work more fully elsewhere.

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Normal Resistance-level of *Anopheles funestus* Giles to Insecticides

The tolerance to insecticides of normal and resistant strains of *A. gambiae* Giles has been measured by a number of workers[1–3], but so far no figures for *A. funestus*, the second main malaria vector of Africa, seem to have been published. This communication records the results of tests carried out on this species in an area of Sokoto Province, Northern Nigeria, about ten miles west of the sprayed zones of the Western Sokoto Malaria Control Pilot Project. The test for susceptibility described by Busvine[4] was applied to wild-caught females in the blood-fed and gravid states. Results are summarized in Table 1.

These results have been evaluated by the method of Litchfield and Wilcoxon[5], and values for the median lethal concentrations of DDT and gamma-BHC, with confidence limits for 95 per cent probability, are respectively 1·32 per cent (1·39 and 1·24 per cent) and 0·0033 per cent (0·0040 and 0·0027 per cent). In the case of dieldrin the data are significantly heterogeneous as shown by the χ^2 test; the median lethal concentration apparently lies

Table 1

Toxicant	Concentration (per cent)	No. of mosquitoes exposed	Mortality (per cent)
DDT	0·75	33	97
	0·50	69	90
	0·33	90	54
	0·25	47	28
Control	—	27	0
Gamma BHC	0·01	33	90
	0·007	70	71
	0·004	51	60
	0·002	34	29
	0·001	17	0
Control	—	31	0
Dieldrin	0·1	74	81
	0·075	52	35
	0·050	56	27
	0·033	44	14
	0·025	55	4
Control	—	29	0

between 0·05 and 0·1 per cent. The tolerance of *A. funestus* to DDT, therefore, exceeds somewhat the figures given for *A. gambiae* by Busvine[2] and Davidson[3]. The species appears, however, to be considerably less tolerant to gamma-BHC and dieldrin than *A. gambiae*.

Apart from experimental error, the cause of the heterogeneity of the response to dieldrin might be either the presence of allied species indistinguishable in the adult stage from *A. funestus* (*A. rivulorum* or *A. leesoni*), or the presence of strains of *A. funestus sensu stricto* of different tolerance-levels. The allied species have not been recorded in the larval stage from the area, while the proximity of the dieldrin-sprayed zone of the Pilot Project, in which *A. funestus* has not been eradicated, means that the possibility of the presence locally of selected strains differing in tolerance to this toxicant cannot be entirely discounted.

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Brown Stain formed on Wet Cellulose

The phenomenon of the 'brown stain' formation on wet cellulosic materials was reported[1] in 1934 and has since been studied by Turner[2] and his colleagues at Manchester, and by Appel[3] and others in the United States, but does not even yet seem widely known. As the effect may be encountered in paper chromatography and with the Weisz[4] 'ring-oven', it may save trouble to workers in those techniques if attention is directed to it. The effect can readily be seen by putting a strip of filter paper as a wick in distilled water. In a few hours a brown stain is found at the top of the wick, or of its wet portion. The immediate neighbourhood of the stain has a brilliant white fluorescence under ultra-violet light and is strongly dyed by methylene blue (0·1 per cent in water).

The mechanism of the effect is twofold, being in part the formation of a degradation product of cellulose by oxidation at the wet–dry boundary[2,3] and in part, as has recently been found in this Inspectorate, the capillary concentration of the same or a similar product already in the paper. It is found that the amount of this material present is proportional to the age of the paper, and that its formation is accelerated by increasing temperature, the rate doubling for each 10 deg. C. rise.

When distilled water is run through filter paper on the ring-oven, a brown ring is formed which could easily mask, or be mistaken for, a precipitate of a metal compound. Under ultra-violet light, however, the ring fluoresces strongly, and it is strongly dyed by methylene blue. The effect can be largely eliminated by washing the filter paper before use.

The reason that this very common effect with wet paper or cotton has not been remarked upon more often may well be that the stain looks like a rust stain and is often met with in circumstances in which the material is liable to wetting with water which may contain iron. Thus a cotton curtain which had been in contact with a steam pipe had developed deep yellow stains, which looked exactly like rust stains, but which were found to fluoresce strongly under ultra-violet light, to be dyed by methylene blue and, in fact, to contain negligible iron.

Details of the preliminary results briefly mentioned here, as well as of the behaviour of some non-aqueous liquids and non-cellulosic materials, are being published elsewhere.

H. R. Ambler
C. F. Finney

Chemical Inspectorate,
Ministry of Supply,
Station Approach Buildings,
Kidbrooke,
London, S.E.3.
March 6.

[1] Bone, W. H., *J. Soc. Dyers and Colourists*, **50**, 307 (1934).
[2] Turner, H. A., *Proc. Paper Makers Assoc.*, **19**, 182 (1938). Bone, W. H., and Turner, H. A., *J. Soc. Dyers and Colourists*, **66**, 315 (1950). Madaras, C. W., and Turner, H. A., *ibid.*, **69**, 371 (1953).
[3] Bogaty, H., Campbell, K. S., and Appel, W. D., *Textile Res. J.*, **22**, 75 (1952). Schaffer, R., Appel, W. D., and Forziati, F. H., *J. Res. Nat. Bur. Stand.*, **54**, 103 (1955).
[4] Weisz, H., *Mikrochim. Acta*, 140 (1954).

Mutation to Virulence in *Cladosporium fulvum*

The origin of physiological races of fungi causing plant diseases has been attributed to sexual and parasexual recombination, adaptation and mutation. Where pathogenicity depends on the action of several genes, recombination results in new physiological races. Where pathogenicity on a given host depends on a single gene, changes in host specificity can only arise by point changes within the gene as distinct from recombination.

Attempts have been made to induce host-range mutants in plant pathogenic bacteria and fungi but the changes brought about have mostly been unspecific increases or decreases of vigour[1]. More recently, induced changes in relation to specific host genes for resistance have been studied in *Cladosporium fulvum* on tomato[2] and *Melampsora lini* on flax[3]. Experiments with a variety of induced auxotrophic mutants of *C. fulvum* have failed to reveal either heterocaryosis or somatic recombination. Since the sexual stage is also unknown it seems likely that physiological races have arisen in Nature by mutation.

In this communication we are concerned with race 0 and race 2, and the mutational step, race 0 → race 2. Race 0 is avirulent, but race 2 is virulent on the tomato variety Vetomold, homozygous for resistance gene Cf_2. Conidia of race 0 were treated with a mutagen and inoculated to Vetomold, so that virulent mutants might be recovered from any lesions that occurred. In order that contaminants could be recognized and discarded, a strain of race 0 carrying a marker induced by X-rays was used[4]. Its host-range was wild type but it produced red pigment instead of purple.

Reconstruction experiments showed that with about ten virulent conidia of race 2 per ml., the presence of avirulent conidia of race 0 reduced the absolute number of lesions on Vetomold. This reduction was proportional to the concentration of avirulent conidia over the range 5×10^4 to 10^6 per ml. The lowest number of virulent conidia in the highest concentration of live avirulent conidia to give one lesion was of the order of 17 to 10^6 at a concentration of 5×10^5 per ml. This gives a measure of the sensitivity of the selective method.

Conidial suspensions of race 0 treated with X-rays or ultra-violet radiation at doses to give 90–95 per cent kill were inoculated to the host plants directly. No mutants were recovered. This failure may be due to: (i) delay in the expression of a mutation to virulence for a few cell divisions during which time the growth of the conidial germ tube in the host is blocked; (ii) the conidium of *C. fulvum* is frequently two- or three-celled. Each cell is uninucleate, and a germ tube is produced by the cell at each end of the conidium. If only one nucleus mutates to virulence, and other wild type nuclei are viable, the avirulent reaction of the germ tube from a sister cell might inhibit the growth of the mutant; (iii) the mutation-rate in these experiments, although perhaps near enough to the threshold-rate of 17 per 10^6 live conidia, did not give rise to enough mutant conidia per ml. to give a lesion.

If a period of growth on a neutral medium is allowed to follow irradiation of young mycelium, the conidia which develop after irradiation, if they carry a mutation, may be expected to have this mutation in all their nuclei. The period of growth between the mutation and the formation of new conidia will give time for expression of the mutant phenotype. It should also enable the number of mutant nuclei to multiply, and in turn give a sufficiency of mutant conidia for infection.

Five-day old plate cultures of the red mutant of race 0 were irradiated with varying doses of X-rays and ultra-violet radiation. Four days after treatment, conidial suspensions were prepared from the treated plates and inoculated to test plants. One treatment, receiving 3,750 r. X-rays, gave 96·00 per cent germination of the conidia in the inoculum, determined by plating. Among 11 isolates from susceptible lesions on the test plants in this treatment, 10 were contaminants with wild-type pigment. The other one was indistinguishable from the original red mutant of race 0 except for virulence on Vetomold. This suggests that it was a genuine mutant and not a contaminant.

Flor[3] produced new physiological races of *Melampsora lini* by treating a dicaryon heterozygous for certain virulence genes, with ultra-violet radiation. The virulence alleles are recessive but can operate in a monocaryon or a homozygous dicaryon. Some of the changes in virulence reported could thus be due to partial or even complete chromosome deletions caused by the ultra-violet treatment which would result in the unmasking of the recessive virulence allele. Changes of this kind could only be distinguished from a point change by a breeding test to see if the dicaryon were homozygous or hemizygous at the locus concerned. Such changes in *C. fulvum*, which is a haploid monocaryon, would probably be lethal.

If mutations to virulence in general can be obtained by such destructive agents as X-rays and ultra-violet radiation then it has an obvious moral for those who advocate wholesale treatment of plant material with radiations. The increase in virulence due to unintentional treatment of pathogens may more than offset host improvements[5]. These changes also have implications for any hypothetical mechanism of host resistance and susceptibility. One may speculate that a resistant reaction involves a primary interaction between host and parasite, which is followed by the development of blocking mechanisms that inhibit the growth of the parasite and may cause localized injuries in the host. If the parasite substance taking part in the primary interactions were lacking or sufficiently changed the resistance reaction would not be set off, and the host would be susceptible. A mutation of this kind, in a pathogen, might well be produced by X-ray or ultra-violet treatment.

P. R. Day

John Innes Horticultural Institution,
Bayfordbury,
Hertford, Herts.

[1] Lincoln, R. E., and Gowen, J. W., *Genetics*, **27**, 441 (1942).
[2] Day, P. R., Ph.D. thesis, University of London (1954).
[3] Flor, H. H., *Science*, **124**, 888 (1956).
[4] Day, P. R., *Microbiol. Genet. Bull.*, **9**, 6 (1954).
[5] Harland, S. C., Third Bateson Lecture, John Innes Horticultural Institution (1955).

Gene-controlled Sterility in the African Mouse (*Mastomys*)

A small stock of *Mastomys natalensis* was imported into England early in 1952. These animals were of the normal dark brown colour.

In their first generation they produced a number of pale grey offspring which were more attractive than their normally coloured brothers and sisters and were selected for breeding. They produced nothing and the pairs were recombined, without any result. Finally, grey animals were mated with normally coloured ones. The grey females then produced offspring; but the grey males, though seen to copulate, sired nothing.

The grey males seemed normal in behaviour and anatomy, but histological examination of the testes revealed an abnormal spermatogenesis. Spermatogonia and primary spermatocytes were present, but there were no spermatids or spermatozoa. Instead the tubules contained a number of free floating, giant, multinucleate cells. Examination of the epididymis confirmed the situation seen in the testes. The tubules of the normal epididymis were distended with spermatozoa whereas those of the other were empty.

A number of normal and grey animals have been examined and the results found to be the same in each case. All the normally coloured animals had normal testes, whereas all the grey animals had abnormal testes. The numbers of each type produced suggested that coat colour and sterility are controlled by a single pair of genes. Breeding experiments are continuing.

It is understood that there are several stocks of this rodent in Great Britain. I would be glad to hear from any breeder who has had a similar experience.

J. I. Menzies

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Chelsea Polytechnic,
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Jan. 21.

Cytological Examination of Herbarium Material of Hepatics

It has been found that, when leaves from near the apex of dried herbarium material of various leafy hepatics (Jungermaniales Acrogynae) are stained in acetocarmine, certain of the nuclear components are clearly visible. In *Frullania squarrosa*, female material thirty-three years old and male material two years old have been examined and found to show clearly the heteropycnotic sex chromosomes, heteropycnotic fragments of other chromosomes, and the nucleolus. All these features are also distinguishable after staining of fresh material. Since the sex chromosome mechanism in this species and in other species belonging to the subgenus *Galeiloba* is an $X1$-$X2$-Y mechanism[1,2], the sex of the material may be determined by counting the number of heteropycnotic chromosomes.

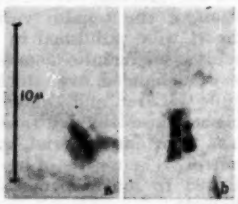

Fig. 1. (*a*) Male material dried for two years, showing one heteropycnotic chromosome and heteropycnotic fragments of other chromosomes. (*b*) Female material dried for thirty-three years, showing two heteropycnotic chromosomes and heteropycnotic fragments of other chromosomes

Results with other material have been variable. Sporophytes of *Frullania patula* collected ten years ago showed nucleoli but not heteropycnotic chromosomes in spore mother cells and elaters. Gametophyte material of *Plagiochila squamulosa* collected nine years ago also showed only nucleoli, but since there were two nucleoli in some of the cells the examination showed that this species was probably diploid. The variability of the results obtained may be due to variations in the rate of drying of the material after collection and the conditions of storage.

The cytological examination of herbarium material may be useful in two ways. First, it is a possible way of sexing sterile herbarium specimens of certain hepatics, and of checking on the sex mechanism in species of which fresh material is not available. Secondly, if the normal complement of heteropycnotic chromosomes and nucleoli in related species is known, it is a way of discovering possible polyploid races in herbarium material.

G. K. Berrie

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March 4.

[1] Lorbeer, G., *Jahrb. f. Wiss. Bot.*, **80**, 565 (1934).
[2] Tatuno, S., *Bot. Mag. Tokio*, **50**, 526 (1936).

A Modification of the Hensen–Stempel Pipette

Although widely used in plankton studies, the Hensen–Stempel pipette does not seem to have been employed for investigations of the microbenthos. Clearly, its use or potential use is important, since efficient sub-sampling of soil extracts can reduce possible errors in estimates of population; but it cannot be used in its normal form owing to the presence of fine particles in the extracts.

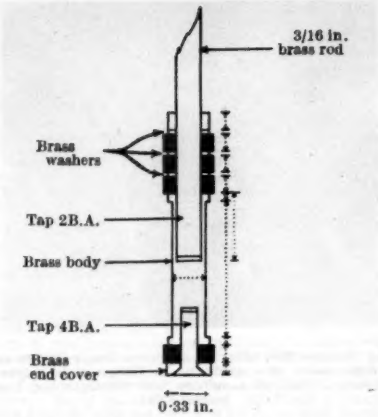

Fig. 1. ■, Neoprene washers

Those who are familiar with the Hensen–Stemple pipette[1] will recall that the required volume is taken up in a hollowed portion, the top and bottom of which fit the outer cylinder tightly; while above the top is a series of metal and cork washers which also fit the outer cylinder tightly.

To overcome the effects of fine soil particles caught up in and grinding away the working parts, a piston of the type shown in Fig. 1 was adopted; a chamber designed to hold 1 c.c. gave a constant delivery of 1·1 c.c. over many trials. Although following the basic type, it will be seen that the modification departs from it by use of 'Neoprene' washers which alone fit the outer chamber tightly, the metal washers being so designed that there was sufficient clearance to prevent undue abrasion or jamming. The 'Neoprene' washers, although capable of a tight fit, were sufficiently soft to allow the soil particles to press into them and so reduce undue wear on the outer cylinder.

Few measurements are given in the figure, to avoid confusion; the distance between two dots on the dimension lines is 1/32 in.

E. J. Perkins

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[1] For example, Welch, P. S., "Limnological Methods", see p. 282 (Country Life Press, New York, 1948).

Antagonistic Effects of *Alternaria tenuis* on Certain Root-fungi of Forest Trees

Alternaria tenuis has been observed to produce antagonistic effects on a number of mycorrhiza-formers for ectotrophic tree species. The two active strains of *A. tenuis* tested were isolated from two forest nursery soils of the arable type in which this fungus is generally abundant. Reactions of the mycorrhizal mycelia to the antagonistic principle of *A. tenuis* were recorded for mixed cultures on a synthetic medium (glucose, 20 gm.; magnesium sulphate, 0·1 gm.; ammonium chloride, 0·5 gm.; potassium dihydrogen phosphate, 1 gm.; malt extract, 20 gm.; agar, 15 gm.; distilled water,

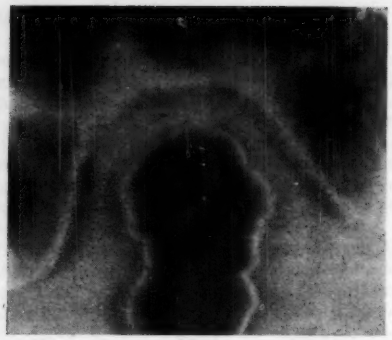

Fig. 1. Antagonistic effect of *Alternaria tenuis* (centre culture) on *Boletus scaber* in a synthetic medium; eight weeks from inoculation. (Part of a culture flask photographed from the reverse side)

1,000 c.c.) in the following order of degree: *Boletus granulatus*, *B. variegatus*—markedly inhibited; *B. bovinus*, *Rhizopogon luteolus*—inhibited; *B. scaber*—mildly inhibited. The accompanying photograph demonstrates the condition of *B. scaber* eight weeks from inoculation.

Dr. P. W. Brian, who tested the effect of culture filtrates of a strain of *A. tenuis* under observation on three mycorrhizal fungi, was able to confirm the results obtained in mixed cultures. He recorded *B. scaber* to be less inhibited than *B. bovinus* and *Rhizopogon luteolus* (*B. variegatus* and *B. granulatus* were not tested against the culture filtrates).

Pseudomycorrhizal fungi, that is, forms of *Mycelium radicis atrovirens* and *Rhizoctonia*-like mycelia, did not show any effects from *A. tenuis* in mixed cultures on the nutrient medium referred to above and on a number of other media employed, including corn-steep.

The reactions of the mycorrhizal mycelia to *A. tenuis* seem to represent a parallel phenomenon to the effects induced by species of *Penicillium* as described by Brian[1], who reported a differential susceptibility of mycorrhizal fungi to gliotoxin produced by a *Penicillium* species active in the heathland soil of Wareham (Dorset). *B. bovinus*, observed by Brian to be less affected than the other ectotrophic fungi tested, is the only mycorrhiza-former of forest trees which is initially present in this particular heathland soil[2]. It is of interest that *B. scaber*, found to be least inhibited by the fungistatic properties of *A. tenuis*, has been successfully inoculated, on various occasions, into nursery soils of the arable type in which other mycorrhizal mycelia, more markedly affected by *A. tenuis*, fail to grow. In this connexion it is also noteworthy that pseudomycorrhiza-formers, recorded to be unaffected by *A. tenuis*, are generally abundant in the soils under consideration and, if not present initially, may easily be introduced.

Since there is no experimental evidence (as yet) that the reactions of the root-fungi to *A. tenuis* in the natural soil are similar to those observed on synthetic media, it seems too early to suggest that the fungistatic property of *A. tenuis* may be responsible, at least in part, for the absence of certain mycorrhizal activities under field conditions. However, one feels tempted not to dismiss the attractive hypothesis of a possible relationship between the antagonistic behaviour of *A. tenuis* to mycorrhiza-formers and the poor growth of young trees which, in the soils under observation, is invariably accompanied by a lack of true mycorrhizal associations and, at the same time, by a noticeable profusion of pseudomycorrhizal infections. Experiments designed to analyse certain factors involved in this hypothetical relationship are in progress.

Ida Levisohn

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March 1.

[1] Brian, P. W., *Nature*, **155**, 637 (1945).
[2] Rayner, M. C., *Nature*, **158**, 174 (1945).

Tomato Grafting Experiments at Tihany

The results of our grafting experiments made on the F_1 generation of the tomato varieties Golden Apple and Oxheart were published in 1951. These experiments resulted in definite genetical changes[1]. Further results were handed over during a visit to Hungary to Anne McLaren and Donald Michie, and they were published in *Nature*[2]. I sent Dr. A. J. Bateman samples from our material, at his request, for genetical control. The results of his investigation were communicated to me in personal letters also published in *Nature*[3].

The changes we had observed were of two kinds: (1) changes of sexual hybrid character, with segregation in the progenies, and (2) mutation-like changes without segregation. Plants belonging to the first group are, according to Bateman's results, presumably sex-hybrids, and the changes we had observed[1] referred to quantitative characters. Leaving aside Prof. J. B. S. Haldane's explanation[4] that the inheritance of characters may be attributable to virus transduction, I can only explain the occurrence of these sex-hybrids as due to lack of care. In that summer there were in the greenhouse many tiny insects, including thrips, and the simple isolation with cotton must have been insufficient. It is also possible that, under the influence of the stock, cross-fertilization could have happened more easily ('vegetative approximation').

In the cases of non-segregating types, Bateman[3] refers also to the possibility that these are the results of grafting. I cannot accept the supposition that the Oxheart material originally used was polymorph. Both varieties had been regularly inbred by us since 1946, and neither spontaneous cross-fertilization nor mutation-like changes had been observed. I must also emphasize the fact that these non-segregating types have no practical importance.

I am very grateful to my English colleagues for their interest, and especially to Dr. A. J. Bateman for his criticisms and the exact genetical evaluation by which he demonstrated the correct interpretation of our work.

L. J. M. Felföldy

Department of Botany,
Biological Research Institute of
Hungarian Academy of Science,
Tihany Lake Balaton.
Feb. 2.

[1] Felföldy, L. J. M., *Acta Biol. Acad. Sci. Hung.*, **2**, 3 (1951).
[2] McLaren, Anne, and Michie, D., *Nature*, **174**, 390 (1954).
[3] Bateman, A. J., *Nature*, **175**, 1118 (1955).
[4] Haldane, J. B. S., *New Biol.*, **19**, 7 (1955).

FORTHCOMING EVENTS

Monday, June 3

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. D. L. Botting: "Oxford Expedition to Socotra".

Tuesday, June 4

PHYSICAL SOCIETY (in the Lecture Theatre of the Science Museum, Exhibition Road, London, S.W.7), at 4.45 p.m.—Annual General Meeting. Prof. N. F. Mott, F.R.S.: Presidential Address.

INSTITUTION OF THE RUBBER INDUSTRY (at the Royal Society of Tropical Medicine and Hygiene, 26 Portland Place, London, W.1), at 6 p.m.—Mr. G. F. Oesterling (U.S.A.): "Special Purpose Rubbers".

Wednesday, June 5

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. W. S. Pitcher, Prof. H. H. Read, F.R.S., Mr. R. L. Cheesman, Dr. I. C. Pande and Mr. C. F. Tozer: "The Main Donegal Granite".

SOCIETY FOR ANALYTICAL CHEMISTRY, MICROCHEMISTRY GROUP (in the restaurant room of "The Feathers", Tudor Street, London, E.C.4), at 6.30 p.m.—Discussion Meeting on "The Micro-Determination of Functional Groups", opened by Dr. W. I. Stephen and Mr. G. Ingram.

Wednesday, June 5—Friday, June 7

INSTITUTE OF NAVIGATION (joint meeting with the INSTITUT FRANCAIS DE NAVIGATION and the AUSSCHUSS FUR FUNKORTUNG, at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7)—Conference on "The Avoidance of Collision by Airborne and Shipborne Means".

Thursday, June 6

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Dr. C. G. Butler: "Some Work at Rothamsted on the Social Behaviour of Honeybees".

POLAROGRAPHIC SOCIETY (at the "Duke of York", 8 Dering Street, Mayfair, London, W.1), at 7 p.m.—Informal Discussion Meeting.

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Scientific Papers.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT IN MATHEMATICS—The Secretary of University Court, The University, Glasgow (June 7).

RESEARCH FELLOW IN MATHEMATICS—The Secretary of University Court, The University, Glasgow (June 7).

SENIOR TECHNICIAN IN PHYSICS IN THE X-RAY DIAGNOSTIC DEPARTMENT, for duties which will include the care and maintenance of apparatus, radio-protection service in the Department, and the supervision of the dark-room technicians—The Secretary, University College Hospital, Gower Street, London, W.C.1 (June 8).

RESEARCH ASSISTANT (man or woman, preferably with an honours degree in medical science or biology and a knowledge of German) IN THE DEPARTMENT OF ANATOMY, for work mainly on the central nervous system—The Secretary, University College, Gower Street, London, W.C.1 (June 10).

LEVERHULME STUDENT (with a postgraduate diploma in chemical engineering or equivalent qualifications) IN CHEMICAL ENGINEERING; and an ASSISTANT LECTURER (with good honours degree) IN PURE MATHEMATICS—The Registrar, King's College, Strand, London, W.C.2 (June 11).

LECTURER IN APPLIED MATHEMATICS—The Secretary, The Durham Colleges in the University of Durham, 38 North Bailey, Durham, (June 12).

LECTURER (Grade I or Grade II) IN APPLIED MATHEMATICS at the University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (June 14).

READER IN PURE MATHEMATICS; a READER IN APPLIED MATHEMATICS; and a LECTURER IN MATHEMATICS at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, June 14).

ASSISTANT LECTURER IN PHYSICS—The Secretary, St. Mary's Hospital Medical School, Paddington, London, W.2 (June 15).

ASSISTANT LECTURERS (2) IN ZOOLOGY—The Registrar, The University, Manchester 13 (June 15).

LECTURER or ASSISTANT LECTURER (with a special interest and qualifications for teaching political philosophy) IN PHILOSOPHY—The Registrar, The University, Manchester (June 15).

MAP CURATOR/LIBRARIAN (preferably with qualifications in geography and librarianship) IN THE DEPARTMENT OF GEOGRAPHY—The Registrar, The University, Sheffield (June 15).

RESEARCH ASSISTANT (graduate in mathematics, physics, chemistry, fuel technology, chemical engineering, or mechanical engineering) TO THE PROFESSOR OF FUEL TECHNOLOGY AND CHEMICAL ENGINEERING—The Registrar, The University, Sheffield (June 15).

SENIOR LECTURER IN ANCIENT PHILOSOPHY—The Secretary, The University, Edinburgh (June 15).

SENIOR LECTURER or LECTURER IN PHARMACOLOGY—The Registrar, The University, Sheffield (June 15).

BIOCHEMIST, Basic grade (with a science degree), at Doncaster Royal Infirmary—The Group Secretary, Doncaster Hospital Management Committee, Doncaster Royal Infirmary, Doncaster (June 16).

ASSISTANT LECTURER (preferably woman) IN CHEMISTRY; and an ASSISTANT LECTURER (preferably woman) IN PHYSICS—The Principal, Royal Holloway College, Englefield Green, Surrey (June 17).

LECTURERS (2) (with interests in the physico-chemical aspects of biology) IN THE BIOPHYSICS UNIT—The Secretary, The University, Edinburgh (June 17).

SENIOR SCIENTIFIC OFFICER (with an honours degree in biochemistry or an equivalent qualification and research experience in proteolysis) IN THE BIOCHEMISTRY DEPARTMENT, for work which will involve fundamental studies on the effects of enzymes on the caseins that occur in milks—The Secretary, Hannah Dairy Research Institute, Kirkhill, Ayr, Scotland (June 17).

LECTURER (with good academic qualifications and practical experience in any section of the electrical engineering industry) IN ELECTRICAL ENGINEERING—The Registrar, The University, Leeds 2 (June 18).

ASSISTANT LECTURER (preferably with experience in experimental zoology and/or comparative physiology) IN ZOOLOGY—The Registrar, The University, Leeds 2 (June 19).

ASSISTANT IN THE DEPARTMENT OF GEOLOGY, for duties which include the registration, indexing, preservation and care and maintenance of exhibition material; assistance in the preparation of exhibition lay-outs; use and routine maintenance of scientific instruments—The Director, Royal Scottish Museum, Edinburgh 1 (June 20).

RESEARCH FELLOW (with the degree of Ph.D., or some postgraduate experience) IN THE DEPARTMENT OF GEOLOGY—The Deputy Registrar, The University, Edgbaston, Birmingham 15 (June 21).

POLYMER CORPORATION POST-DOCTORAL RESEARCH FELLOW to collaborate with Dr. P. H. Plesch on cationic polymerization—The Registrar, University College of North Staffordshire, Keele, Staffs (June 22).

UNIVERSITY ASSISTANT LECTURER IN THE FACULTY OF MORAL SCIENCE to take part in the teaching of Symbolic Logic and Foundations of Mathematics—Dr. C. Lewy, Secretary of the Appointments Committee of the Faculty of Moral Science, 49 de Freville Avenue, Cambridge (June 22).

ASSISTANT LECTURER (preferably with some experience in biochemistry) IN THE DEPARTMENT OF BACTERIOLOGY in the Faculties of Science and Medicine—The Registrar, The University, Manchester 13 (June 24).

FELLOW IN THE DEPARTMENT OF NUCLEAR PHYSICS; and a FELLOW (chemist, with experience in vacuum techniques and mass spectrometry) IN THE DEPARTMENT OF RADIO-CHEMISTRY, Research School of Physical Sciences, Australian National University, Canberra—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, June 24).

RESEARCH ASSISTANT (with a degree in botany, biochemistry or microbiology) IN THE DEPARTMENT OF BOTANY, for research on the biochemistry of micro-organisms; and a RESEARCH ASSISTANT (with a degree in botany, biochemistry or microbiology, and preferably with an interest in genetics) IN THE DEPARTMENT OF BOTANY—The Secretary, University College, Gower Street, London, W.C.1 (June 24).

ALMROTH WRIGHT FELLOW (with a first- or second-class honours degree in science), for research work in medical microbiology or immunology—The Secretary, Wright-Fleming Institute of Microbiology, St. Mary's Hospital Medical School, Paddington, London, W.2 (June 29).

ASSISTANT LECTURER or LECTURER (honours graduate in botany or agricultural botany) IN AGRICULTURAL BOTANY—The Registrar, Room 9 (O.R.B.), The University, Reading (June 29).

RESEARCH STUDENT IN ORGANIC CHEMISTRY, for work on the synthesis of high polymers related to coal—The Secretary, The University, Exeter (June 29).

EXPERIMENTAL OFFICER IN THE DEPARTMENT OF INSECTICIDES AND FUNGICIDES, to assist in the development of analytical techniques (particularly traces of insecticides in biological materials, soil, etc.)—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (June 30).

LECTURER IN PSYCHOLOGY in St. Salvator's College—Joint Clerk to the University Court, The University, St. Andrews (June 30).

LECTURER (with an honours degree, and undertaken postgraduate research in experimental or theoretical physics) IN PHYSICS; and a SENIOR LECTURER (with a higher degree) IN PHYSICS at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, June 30).

PROFESSOR OF ZOOLOGY at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Melbourne, June 30).

SENIOR LECTURER IN PHYSIOLOGY at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, June 30).

LECTURER IN BIOCHEMISTRY IN THE RHEUMATISM RESEARCH CENTRE—The Registrar, The University, Manchester 13 (July 1).

RESEARCH OFFICER (with a university honours degree in physics or electrical engineering, together with some postgraduate research experience) IN THE DIVISION OF ELECTROTECHNOLOGY, C.S.I.R., located in the University Grounds, Sydney, to take part in a research programme for (*a*) the development of precision standards and methods of measurement; and (*b*) the investigation of the behaviour of materials under high voltage stress—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 760/94 (July 6).

ASSISTANT LECTURER IN PHYSIOLOGY—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (July 8).

BOTANIST (of high academic standing with a considerable record of personal research, and preferably experience of tropical plantation crops), for work particularly concerned with the study of the growth characteristics of the tea bush in the chief soil climatic regions of East Africa; the study and provision of improved planting material;

and the botanical interpretation of field experiments—The Director, Tea Research Institute of East Africa, P.O. Box 91, Kericho, Kenya, marking envelope "Application" (July 31).

Director of the Commonwealth Bureau of Dairy Science and Technology, Shinfield, near Reading, Berks—The Secretary, Commonwealth Agricultural Bureaux, Farnham Royal, Bucks (September 15).

Mental Health Research Fund Fellows (Senior and Junior), for full-time research work bearing on problems of mental health whether in clinical psychiatry or in one of its supporting sciences—The Secretary, Research Committee, Mental Health Research Fund, 39 Queen Anne Street, London, W.1 (October 1).

Assistant Lecturer in Physics—The Clerk to the Governors, Northern Polytechnic, Holloway, London, N.7.

Chemical Analyst, to serve a research team working on problems on liquid metal alloys for use in advanced nuclear reactors—Prof. J. G. Ball, Metallurgy Department, Imperial College, London, S.W.7.

Demonstrator (honours graduate in botany with at least one year's postgraduate experience in mycology, plant pathology or microbiology) in Horticultural Science—The Registrar, The University, Bristol.

Laboratory Technician (preferably with some knowledge of chemistry, physics, metalwork and woodwork), for work involving the care and maintenance of laboratory equipment in Chemistry, Physics and Biology Laboratories, stockkeeping and apparatus construction—The Principal, City of Worcester Training College, Henwick Grove, Worcester.

Master to teach Mathematics to advanced and scholarship level—The Headmaster, Hutton Grammar School, near Preston, Lancashire.

Principal of Massey Agricultural College (University of New Zealand)—The Registrar, Massey Agricultural College, Palmerston North, New Zealand (September 16).

Senior Lecturer in Metallurgy at Coventry Technical College—The Director of Education, New Council Offices, Coventry.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

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Annual Report on the Progress of Rubber Technology, Vol. 20, 1956. Edited by Dr. T. J. Drakeley. Pp. xi+141+xii. (Cambridge: W. Heffer and Sons, Ltd., 1957. Published for the Institution of the Rubber Industry.) 25*s*. [84

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National Research Development Corporation. Report and Statement of Accounts for the year 1st July, 1955, to 30th June, 1956. Pp. ii+16. (London: H.M. Stationery Office, 1957.) 1*s*. net. [114

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Capital Investment in the Coal, Gas and Electricity Industries. Pp. 12. (Cmnd. 132.) (London: H.M. Stationery Office, 1957.) 8*d*. net. [164

From Comics to Classics: Report on a Conference held on Saturday, November 3, at Church House, Westminster, London. Pp. 32. (London: Comics Campaign Council; The Library Association; National Book League; and the National Union of Townswomen's Guilds, 1957.) [164

Other Countries

United States Department of Agriculture. Farmers' Bulletin No. 2099: Control of Caterpillars on Commercial Cabbage and other Cole Crops in the South. By W. J. Reid, Jr., and F. P. Cuthbert, Jr. Pp. 24. 15 cents. Technical Bulletin No. 1158: Collecting Insects by Airplane in Southern Texas. By Perry A. Glick. Pp. ii+23. 15 cents. (Washington, D.C.: Government Printing Office, 1957.) [94

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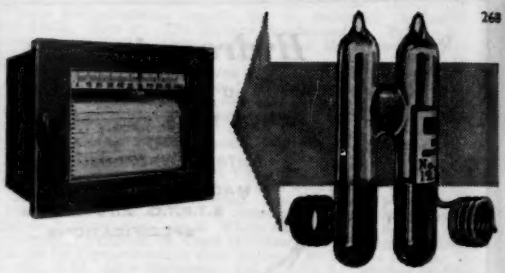

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